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FUTURE DEMANDS ON THE PUBLIC LANDS - VOLUME II: PROJECTIONS OF THE CONSUMPTION OF COMMODITIES PRODUCIBLE ON THE PUBLIC LANDS OF THE UNITED STATES 1980-2000 - A STUDY PREPARED FOR THE PUBLIC LAND LAW REVIEW COMMISSION

Robert R. Nathan Associates
Washington, D.C.

October 1970
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Volume II

Projections of the Consumption of Commodities Producible on the Public Lands of the United States 1980-2000

A Study Prepared
for the
Public Land Law Review Commission

Robert R. Nathan Associates
Washington, D.C.

Republished with revisions
October 1970

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Projections of the Consumption of Commodities Producible on the Public Lands of the United States 1980-2000

by Robert R. Nathan Associates.

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PROJECTIONS OF THE CONSUMPTION OF COMMODITIES PRODUCIBLE ON THE PUBLIC LANDS OF THE UNITED STATES

SUMMARY

The objective of this study was to provide projections of the consumption of commodities producible on the public lands, which can be used as a basis for evaluating the effects of alternative land policies. National and regional projections to 1980 and 2000 are presented both for the commodities producible on the public lands and for those economic and demographic aggregates most likely to reflect the general standards and patterns of life in the United States during the next 30 years. Historical data from 1948-65 were used in most cases to establish the trends on which most of the projections were based. In making the projections, subjective analysis was employed in interpreting trends and selecting appropriate estimating equations, which were determined by regression analysis.

In addition to the four census regions of the United States, projections were made for the 11 contiguous western States (not including Alaska and Hawaii). Low, medium, and high projections were made in most instances, with the medium projections defined as the most likely values of projected variables, and the high or low projections limiting the plausible ranges of variable values. Unless otherwise stated, medium projections only are presented in this summary.

National and Regional Aggregates

National and regional aggregates which will influence commodity consumption and reflect the general standards and patterns of life within the next 30 years include population, labor force, employment, productivity, gross output, industrial production, and personal income.

Population

Projections of national population were based on an examination of demographic trends, including birth rate, death rate, fertility rate, and net immigration. U.S. Bureau of the Census Series C fertility assumptions were assumed, resulting in projections of total national populations of 235.2 million in 1980 and 307.8 million in 2000. Prospective migration between regions was accounted for in the regional projections; the complete range of national and regional populations is shown in tables 1 and 2. The distribution of population between urban and rural areas (tables 3 and 4) indicated that by 2000, 82 percent of the national population will be urban.

Labor Force and Employment

The percentage of the population that will comprise the labor force in 1980 and 2000 (60.5 and 62.3 percent, respectively) will be higher than in 1965 (58.8 percent) due to increased participation by women. The possibility that this factor may be outweighed by a trend toward later entry and earlier retirement from the labor force is indicated in the low projections (56.1 and 55.1 percent, respectively), which are below the 1965 level.

Employment was assumed to be 96 percent of the labor force in both 1980 and 2000 (table 6), taking into account both the ability of the economy to use the services of an increased labor force and increased output per employed person. Regional employment was projected on the basis of historical employment-to-unemployment ratios in each region, and incorporates the tendency toward narrowing regional differentials (tables 6 and 7).

Productivity and Gross National Product

The projected rate of increase of productivity assumed an annual growth rate of 2.6 percent in real output per employed person. This rate, with the projected increases in employment, resulted in annual real gross national product (GNP) rates of 4.4 percent for the period 1965-80 and 4.2 percent for the period 1965-2000 (tables 9 and 10). Gross national product is projected to be $1,176 billion in 1980 and $2,603 billion in 2000. Projected components of GNP are:

	Billion 1958 dollars		
	1965	1980	2000
Personal consumption expenditures..	398	773	1,606
Gross private domestic investment..	98	189	416
Government purchases of goods and services.........................	114	206	567
Exports..........................	38	76	193
Imports..........................	32	68	180
Personal disposable income is projected to be.....................	451	859	1,784

Industrial Production

Taking into account the projected levels of GNP and its components, projections were made for the Federal Reserve Board indexes of industrial production, giving total indexes of 308 and 605 for 1980 and 2000, respectively, compared with the actual total index of 143 in 1965 (1957-59 equals 100).

Gross Product Originating and Personal Income

Projections of gross product originating (GPO) in each region and regional personal income (tables 15-19) incorporate historical trends of product distribution among regions. Following are the projections of the sectorial distribution of national GPO:

	Million 1958 dollars		
	1960	1980	2000
National GPO.........	484,482	1,176,500	2,602,700
Agriculture.........	23,334	30,600	41,600
Manufacturing.......	138,583	385,900	788,200
All other sectors...	322,565	760,000	1,782,900

National personal income is projected to be $935.3 billion in 1980 and $2,069.2 billion in 2000.

Agricultural Commodities and Forages

Projections of the domestic consumption of selected agricultural commodities in 1980 and 2000, including leading feed and food grains, fibers, meats, and forages, were based mainly on multiple regression equations.

Grains and Soybeans

The total consumption of wheat for food should increase slightly during the next 40 years, but probably at a rate significantly lower than population. Corn used by the corn refining industry should increase at a faster rate than population. Per capita use of other grain products for food should remain at approximately current levels. Specific projections, summarized in table 20, include 16.2 million tons of wheat for food in 1980 and 17.5 million in 2000, compared with 15.2 million in 1965. Total all grains for 1965, 1980, and 2000 are 26.6, 31.6, and 38.8 million tons, respectively.

The quantity of grains fed to livestock and poultry in 1980 will be between 27 and 47 percent more than 1965 consumption, and between 90 and 146 percent more by 2000. Comparable increases are projected for soybeans processed in this country for oil and meal, but the rate of growth in the domestic use of this commodity is projected to be somewhat lower than the 1948-65 rate.

Projections of exports of soybeans, wheat, and feed grains not only reflect patterns of world trade since 1954, but also possible shortages of foreign exchange among most free world developing nations and U.S. policies concerning foreign aid. Projected exports of wheat, feedgrains, and soybeans indicate that, by 1980, wheat and flour exports should be roughly twice the amount used domestically for food, and approximately three times such domestic use in 2000. Most wheat sales will continue to be made on a concessional basis, or under noncommercial credit arrangements. Commercial sales of wheat are not expected to increase proportionately. Total wheat exports should double by 2000, compared with 1965 shipments.

Feed grain and soybean exports are projected to increase at significantly higher annual rates than wheat shipments, although historical growth rates actually attained since 1954 probably will not be exceeded. Compared with 1965 levels, feed grain exports by 1980 are projected to be between 51 and 83 percent higher, and 188 to 241 percent higher by 2000. The projections of soybean exports indicate that quantities shipped in 1980 and 2000 will be 150 and 330 percent, respectively, above 1965 exports (table 24).

Forages and Meat

Annual total feed nutrients obtained by cattle and sheep from forage are projected to increase approximately 50 percent by 1980 and over 110 percent by 2000, compared with recent levels (table 25). The feeding value that livestock will obtain from grazing is projected to increase approximately the same relative amount as the total feed nutrients obtained from mechanically harvested forage. The projections of livestock inventories indicate that most of the increase in total roughage consumption will be related to moderate increase in roughage-consuming animals. Nearly all of this increase should be in beef cattle since no increase in dairy cows is in prospect. Changes in numbers of sheep in the foreseeable future should not materially influence national forage requirements.

Beef consumption is projected to continue to grow significantly faster than population, and the annual rates of increase in consumption through 2000 should be slightly higher than the 2.9 percent per year attained during the past 20 years. This increase in beef eating reflects a continued strong consumer preference for beef, compared with other red meats. Veal consumption is projected to decline materially during the next 40 years. Prospects for lamb eating are less determinable: under most assumptions, total lamb consumption will increase at least modestly. Per capita consumption by 2000 is projected to be at least as high as recent levels, and may well be slightly higher (table 26). Exports of these selected meats from the United States should continue to be negligible, compared with domestic consumption, during the rest of this century.

Cotton (Lint) and Wool

Cotton fiber consumption in the United States is projected to remain relatively constant and per capita consumption should continue to decline through 2000. All of the net decline in domestic consumption will be accounted for by declines in demand for this fiber for industrial and household uses; apparel manufacturers will increase their total consumption of cotton (table 27).

The per capita consumption of wool, which has been decreasing in recent years, is expected to continue to decline. Because of population increases, however, the total consumption of wool is projected to increase by both 1980 and 2000 (table 29).

Chemicals and Fertilizer

Projections of the domestic consumption of phosphate rock, potash, and sulfur, by principal end-uses or intermediate products, were based mainly on regression analyses developed to explain annual variation in use during 1948-65. Export shipments were projected independently of domestic use. Subjective analyses led to estimates of how prospective fertilizer consumption in foreign free world countries might alter recent trends in U.S. exports of these fertilizer raw materials.

Phosphate Rock

Developments in phospatic fertilizer technology will be the prime determinant of phosphate rock consumption in the United States during the next 30 years. Projections allowed for the fact that widespread acceptance of major improvements in the chemical efficiencies of phosphatic fertilizers could create unprecedented demands for phosphate rock.

By 1980, total phosphate rock consumed domestically by fertilizer manufacturers and other chemical-using industries is projected to be between 37 and 49 percent above 1963-65 levels, if improvements in fertilizer technology turn out to be minor. Consumption is projected to increase to nearly 12 million tons, or 140 percent above recent levels, by 1980 if major technological advances and their commercial exploitation should occur. Regardless of future technological developments, however, significantly larger portions of phosphate rock will be reduced to phosphoric acid before being made into agricultural and industrial products for domestic consumption or export. Between 1980 and 2000, use of phosphates by agriculture and industry should increase at slightly lower annual rates than between 1965 and 1980.

Projections of exports of phosphates indicate that the dynamic growth in foreign sales attained since 1954 probably will continue. By 1980, exports of phosphates could well exceed domestic consumption, and foreign shipments by 2000 will exceed domestic use by 66 to 83 percent. Major advances in phosphatic fertilizer technology in this country, however, would reduce substantially the relative importance of projected foreign sales compared with total consumption of U.S. phosphate rock.

Potash

Potash used by fertilizer manufacturers is projected to increase at significantly lower rates than phosphates, particularly during the last two decades of this century. Other minor industrial uses of potassium compounds are projected to continue to increase at rates similar to recent increments in annual growth. By 1980, consumption is projected to reach levels between 47 and 59 percent above 1963-65 requirements, and from 81 to 98 percent higher by 2000.

Potash exports will not continue to increase as rapidly as the spectacular expansion which has occurred since 1954. Competition from Canadian and European suppliers will probably curtail additional demands for U.S. potash, at least through 1980. If agronomic needs for potassium fertilizers in free world developing countries prove to be similar to recent experience in commercial agriculture in the developed countries, U.S. potash exports during the 1980's and 1990's would increase nearly as fast as total world fertilizer consumption, unless most of this market is captured by greatly expanded Canadian production.

Sulfur

Sulfur consumption is expected to continue to grow at a constant rate relative to the expansion of industrial production. Projections through 2000 indicate that growth rates during the next 15 years will be similar to those attained since 1948, but the average annual increases during the last two decades of this century will be somewhat smaller. Increasing quantities of sulfur will be converted into sulfuric acid for diverse industrial purposes. By 2000, sulfur consumption will be determined almost entirely by the effective demand for sulfuric acid.

Moderate increases in sulfur exports from 1965 levels seem relatively certain after 1970. Growth rates generated by record demands from foreign fertilizer manufacturers may cause U.S. sulfur exports to increase as rapidly as phosphate shipments, provided ample new sources of sulfur for domestic requirements are developed. Known reserves of native sulfur in the United States should continue to limit exports from this country. Major technological developments for sulfur recovery or extraction from new sources will probably release substantial additional elemental sulfur for export after 1980. Foreign shipments by 2000 are projected to reach levels at least 141 percent above 1965 sales.

Selected Metals and Other Nonfuel Minerals

The metals and nonfuel minerals selected are both important and representative commodities produced from U.S. public lands. The list is not exhaustive, however, and certain important materials were not projected because of the special monetary or strategic character of their uses.

Projections were made for national demand, except for sand and gravel which were also made on a regional basis. For the most part, the estimates used appropriate series and forecasts of Federal Reserve Board indexes of industrial production as independent variables in simple regressions.

Projection of Major Metals

A forecast of iron and steel consumption and exports was made as an intermediate calculation in estimating demand for iron ore and manganese ore. Also, an assumption as to U.S. production of iron and steel (based on a limitation of imports to 15 percent of consumption) was adopted to assist in calculations of fuel and power demand. The figures are higher than other recent estimates because the projections of GNP used reflected the influence of high rates of growth since 1961; the definition of demand is broad, including all forms of iron and steel and imports and exports; no allowance was made for possible supply limitations. The projected total iron and steel demand together with that of the iron ore necessary to make projected quantities of domestically demanded steel for the years 1980 and 2000 are shown in the tabulation below.

Among the nonferrous metals, aluminum and magnesium are expected to continue to grow rapidly in demand. The demand for each is projected to more than double by 1980 and to be five times greater in the year 2000 than in 1965. Copper, lead, and zinc demand will increase more slowly, with the demand for lead expected to be the slowest of all (see tabulation below).

Projections of Minor Metals and Additives

Manganese ore, nickel, molybdenum, tungsten, and vanadium are expected to experience strong growth in demand as high levels of GNP result in continued high demands for high-performance metals. Manganese ore demands in 1980 and in 2000 reflect its use in steelmaking (including manganese ore used to make steel and other products imported by the United States). Demand for these materials will double or more by 1980 and quadruple or more by 2000. The rate of growth for nickel appears low compared with 1965 because that year was one of high nickel consumption.

Demand for diatomite will almost triple in 1980 and will be six times as great in 2000. Sand and gravel, including crushed stone, will also almost triple in 1980, and will reach 11,221.8 million short tons in 2000 as construction demand multiplies with high-level income.

The United States is a net importer of most metals and minerals. For those for which exports are significant, molybdenum (69.4 million tons in 1980 and 139.4 million in 2000) and diatomite (296,500 short tons in 1980 and 603,200 in 2000) head the list. Aluminum is both exported and imported, as is iron ore, but imports predominate.

The following tabulation shows demand (consumption plus exports) for 1965 and projections for 1980 and 2000:

	1965	1980	2000	Unit
Iron and steel	105.6	255.8	451.1	Mil. long tons
Iron ore	132.2	325.2	551.4	do.
Aluminum	3,736.2	9,054.7	19,138.5	Thou. short tons
Copper	2,883.7	4,492.6	7,715.1	do.
Lead	1,241.5	1,365.8	1,701.51	do.
Zinc	1,742.1	2,957.2	9,783.2	do.
Magnesium	83.2	246.0	522.6	do.
Mercury	76.5	152.8	288.2	Thou. flasks
Manganese ore	2,866.1	8,307.6	15,183.9	Thou. short tons
Nickel	172.1	327.6	651.7	do.
Molybdenum	72.7	175.3	249.5	Mil. lbs.
Tungsten	10.4	24.4	51.1	do.
Vanadium	4.7	12.3	22.4	Thou. short tons
Diatomite	580.3	1,482.5	3,016.0	do.
Sand, gravel, and crushed stone	1,685.7	4,561.6	11,221.8	Mil. short tons

Mineral Fuels and Electricity

Projections of the residential, commercial, industrial and transportation consumption of mineral fuels and electricity are based on the methods and projections of the 1963 study by Resources for the Future, Inc.

The consumption of conventional fuels (coal, oil, and gas) in the United States is projected to increase from 52 quadrillion B.t.u.'s in 1965 to between 73 and 86 quadrillion in 1980, and between 108 and 146 quadrillion in 2000. Uranium (U_3O_8) consumption is expected to quadruple by 1980 and double again by 2000.

The industrial use of conventional fuels will show the most rapid rate of growth, increasing by 225 percent, between 1965 and 2000. Transportation consumption, with an increase of 210 percent, will also account for a large share of the incremental market. Direct consumption of conventional fuels for residential and commercial uses is projected to grow by 40 and 100 percent, respectively, for electric generation in 1980 and 2000.

Electricity consumption is projected to increase from 1.2 billion kilowatt hours in 1965 to 2.8 billion in 1980, and to 6.1 billion in 2000. In addition to the conventional

fuels consumed for generation, almost all uranium consumed will be for power generation. Although hydro generation is expected to increase by about 50 percent by 2000, its share of total generation will decline.

Projections of gas consumption indicate an increase from 16.3 trillion cubic feet in 1965 to 27.0 trillion in 1980 and 42.2 trillion in 2000. Two-thirds of the incremental requirement for gas will come from industry, which will more than quadruple its consumption of gas by 2000. Residential and commercial consumption will grow by more than 50 percent, and consumption for electric power generation by nearly two-thirds. Gas is projected to increase its share of the total market for conventional fuels from 33 percent in 1965 to 35 percent in 2000.

Projected oil requirements show an increase from 3.7 billion barrels in 1965 to 5.3 billion in 1980 and to 9.1 billion in 2000. Half the oil consumed in 1965 was for transportation; by 2000, requirements for transportation are projected to nearly treble and to account for over two-thirds of the incremental consumption of oil. Industrial consumption of oil is also expected to increase and to continue to account for about one-tenth of the oil market, but both residential consumption and consumption for electric generation are projected to decline.

Projected coal consumption indicates an increase from 524 million tons in 1965 to 773 million in 1980, and to 1,140 million in 2000. The greatest increase in coal consumption will be for electric power generation, which will account for nearly three-fifths of the incremental coal market between 1965 and 2000. By 2000, electric power plants are projected to consume 636 million tons of coal, compared with 273 million in 1965. Apart from exports, which are projected to double from 50 million tons to 100 million, nearly all of the domestic coal consumed will be for industry, notably for metallurgical uses. An increase from 171 to 396 million tons is projected for industrial consumption from 1965 to 2000. No estimate was made of coal that might be used to obtain oil or gas between 1965 and 2000.

Uranium (U_3O_8) consumption in recent years has been primarily by the Government. Consumption is projected to increase from 10,000 tons in 1965 to 42,000 in 1980, and to 75,000 in 2000, almost entirely for electric power generation by utilities. Generation from nuclear power plants in 1980 is projected to account for 34 percent of the total generation requirements, and 46 percent in 2000. Generation from nuclear power plants was negligible in 1965.

Lumber, Panel, and Woodpulp Products

Projections of the consumption of softwood and hardwood lumber products, veneer and plywood products, and woodpulp products in the United States were based for the most part on recent U.S. Forest Service analyses and procedures revised according to the projected economic aggregates projected in Chapter II.

Lumber and Panel Products

Timber consumption in the United States is projected to increase from 13.5 billion cubic feet of roundwood equivalent in 1962 to 18.9 billion in 1980, and to 23.8 billion in 2000. The proportions of hardwood and softwood used are expected to remain the same through 2000. An increase of 250 percent is expected for woodpulp products between 1962 and 2000, and veneer and plywood products are expected to increase by 200 percent. Lumber products consumption, however, is projected to increase by only 80 percent.

Price-induced substitution and technological changes are the basis for the relatively slow growth rates projected for most uses of lumber. Lumber will tend to be replaced by veneer, plywood, and nonwood products. Lumber consumption is projected to increase from 5.9 billion cubic feet of roundwood in 1962 to 6.5 billion in 1980, and then to decline to 6.2 billion in 2000. Although the amount of lumber consumed for most end uses is expected to increase slightly, the largest consumer of lumber, residential construction, is projected to increase by 11 percent from 1962 to 1980, and then to decline to below the 1962 level by 2000.

The consumption of veneer and plywood products is projected to increase from 1.0 billion cubic feet of roundwood in 1965 to 2.0 billion in 1980, and to 3.1 billion in 2000. The major consumers of veneer and plywood products -- residential and nonresidential construction and manufactured products -- are expected to double or treble between 1962 and 2000. Plastics and other nonwood products will be substituted for panel products to a greater extent, but this will be more than offset by greater use of plywood in place of lumber.

Woodpulp Products

Consumption of paper and board is projected to increase by 175 percent between 1965 and 2000. The proportion of fibrous material in relation to wood used to manufacture paper and board is expected to decline from 22 percent to 15 percent between 1965 and 2000. The amount of woodpulp products required to meet the paper and board demand is projected to increase from 4.8 billion cubic feet in 1965 to 7.6 billion in 1980, and to 13.1 billion in 2000. The proportion of hardwood used in U.S. pulp mills will increase from 30 percent in 1965 to 43 percent in 2000.

Net imports, mostly in the form of newsprint, are expected to account for about 12 percent of consumption in 2000, compared with 17 percent in 1965. Exports of wood products are projected to increase from 0.7 billion cubic feet in 1966 to 2 billion cubic feet in 2000. The export market will probably be split fairly evenly between lumber products and woodpulp products.

Outdoor Recreation

The present and future demand for outdoor recreation is considered in terms of visits to Federal and State recreation lands, outdoor recreation participation on all land, and fishing and hunting licenses.

Recreational Activity on Federal Lands

Projections of visits to Federal lands were based on multiple regression equations, and visits to four types of Federal recreation lands were treated separately -- national parks, other areas administered by the National Park Service, national forests, and wildlife refuges. Projected national park visits for 1980 and 2000 are 84.0 million and 217.8 million, respectively. On a per capita basis, this means almost double the 1965 visits in the coming 15 years (1980), and double again in the next 20 years (2000). In absolute terms, the projection of visits to areas administered by the NPS are 148.2 million for 1980 and 293.3 million for 2000, or 63 per 100 population in 1980 and 95 per 100 population in 2000.

Projected total national forest visits for 1980 and 2000 are 433.0 million and 958.7 million, respectively. This means a doubling by 1980 of visits per 100 population over the 1965 rate and a fourfold increase by 2000. Projections of visits to wildlife refuges are 39.8 million in 1980 and 77.9 million in 2000, a doubling per 100 population between 1965 and 1980, and a further 50-percent increase by 2000.

Recreational Activity on State Lands

Projections of visits to State lands are based on the comparative growth rate of visits to Federal and State lands in 1960 and 1965 and on the assumption that the rates of State Park visits to National Park visits will continue to increase at approximately the same rate as in the past. The projections of visits to State Parks, by regions, are shown in table 54; national projections are 1,290.6 million visits in 1980 and 4,118.1 million in 2000.

Outdoor Recreation

The projections of outdoor recreation participation of all land was based principally on the findings of the 1965 survey conducted by the Bureau of the Census for the Bureau of Outdoor Recreation. Participation, projected by five groups of activities -- passive, physically active, water sports, winter sports, and back-country recreation -- is shown in table 55.

Fishing and Hunting

Multiple regression equations were used in projecting future demand for both fishing and hunting license holders. The national projections for fishing license holders are 32 million in 1980 and 57.6 million in 2000, compared with 20 million in 1965. National projections for hunting license holders are 16.5 million in 1980 and 20.5 million in 2000, compared with 14 million in 1965.

Land Occupancy Requirements

Land occupancy requiremnts were projected for four major nonagricultural land uses: urban land; rural land withdrawn for transportation and other rights-of-way; rural land withdrawn for second homesites; and rural land controlled by the U.S. Department of Defense (DOD) and used for military purposes. The projections were subjective, based on a qualitative review of existing information on past, present, and future land area requirements for the four projected land uses.

Urban Land

Urban land is defined in this report as the land area within which the resident population would be classified as urban because of its size or density, under the definition of urban used by the 1960 U.S. Census of Population. The remainder of the total land area is defined as rural land. In 1960, urban land comprised 23.7 million acres (or 1.25 percent) of the 1,902 million acres of land in the 48 States.

The area encompassed by urban land consists primarily of land which is in use for such purposes as housing, industry, and transportation. In addition, urban land includes a substantial area which is vacant or which is used for such nonurban purposes as farmland and woodland. The proximity of land already used for urban purposes to such land effectively withdraws it from potential long-term use for nonurban purposes. For this reason, the definition of urban land used in this report describes the total land withdrawn by urbanization from potential long-term nonurban use, even though part of this land is not currently being used for urban purposes. The area comprising urban land is projected to increase to 34.7 million acres by 1980 and 48.7 million by 2000.

Rural Land Withdrawn for Transportation and Other Rights-of-Way

Rural land withdrawn for transportation uses is defined as the area of rural land withdrawn by highways, railroads, airports, and utility rights-of-way from primary use for nontransportation purposes. In 1964, rural land withdrawn for transportation uses comprised 25.7 million acres (or 1.35 percent) of the 1,902 million acres of land in the 48 States.

Because of the suitability of utility rights-of-way for multiple uses, and because of the lack of available data on present land requirements for rights-of-way, no attempt was made to project land withdrawals for rights-of-way. Rather, the land requirement for each utility, including electric transmission lines (55,000 volts and above), gas transmission pipelines, and interstate petroleum pipelines, were projected without regard to possible common use of land by the various utilities.

The projection of land requirements for electric transmission lines are 7.6 million acres in 1980 and 9.8 million in 2000, compared with an estimated 3.1 million acres in 1965. Gas transmission pipelines, which required an estimated 217,000 acres in 1965, will require 1.1 million acres in 1980 and 1.3 million in 2000. In 1966, the land requirements of interstate petroleum pipelines were estimated to be 410,000 acres. By 1980, petroleum pipelines will require 577,000 acres, and by 2000, 988,000 acres (tables 60, 61, and 62).

The area of rural land required for locally used rural highways does not appear likely to increase in the future. The area of rural land required for railroad rights-of-way has declined substantially in recent years and will probably continue to decline. The area of rural land required for airports is expected to remain constant, on the assumption that existing airports now located in rural areas will be incorporated in urban areas at approximately the same rate as new rural airport sites are developed. Major increases in the area of rural land withdrawn for transportation rights-of-way are expected to result almost exclusively from increases in land required for State primary highway and Interstate Highway System rights-of-way. It is expected that the rural land area withdrawn for transportation rights-of-way will increase to 26.4 million acres by 1980 and 27.5 million acres by 2000.

Rural Land Withdrawn for Second Homesites

Rural land withdrawn for second homesites is defined in this report as the area of rural land withdrawn by second homes from primary use for other purposes. This definition is intended to include only the rural land area which is primarily used by second-home owners for recreation purposes, and to exclude agricultural and forest land surrounding second homesites which is not primarily used for recreation purposes, although legally owned by the second-home owner.

Measurements of rural land withdrawn for second homesites are not available for the regions and States of the contiguous United States or the Nation as a whole. We estimated that as of 1960 the area of rural land withdrawn by the average second home was 2 acres, and that the total area of rural land withdrawn by second homesites comprised approximately 3.3 million acres (or 0.17 percent) of the 1,902 million acres of land in the 48 States.

The number of second homes increased substantially between 1950 and 1960, and is expected to continue to increase as personal incomes increase and urbanization decreases the accessibility of outdoor recreation opportunities. The number of second homes is projected to increase from 2.0 million in 1960 (of which 1.6 million were rural) to 3.9 million by 1980 (3.1 million rural) and 5.1 million by 2000 (4.1 million rural). Decreasing land requirements for individual rural second homesites are expected to result from the growth of planned rural second-home communities, but the total land area required for second homes is expected to increase to 4.8 million acres by 1980 and 5.7 million by 2000.

Rural Land Controlled by the U.S. Department of Defense and Used for Military Purposes

Rural land controlled by the U.S. Department of Defense (DOD) and used for military purposes includes the following types of land: owned (acquired through purchase, condemnation, donation or transfer); leased; public domain (withdrawn permanently or temporarily by the military department); temporary use (acquired through license or permit, temporary public land order, temporary executive or territorial order); and easements (utility, clearance, etc.). In 1966, the total area of rural land controlled by the Department of Defense and used for military purposes in the 48 States amounted to 22.7 million acres. The land area controlled by the DOD and used for military functions in 1980 and 2000 is not expected to vary substantially in size from the present land area in this category. Medium projections for 1980 and 2000 are, therefore, identical to the 1966 estimate of 22.7 million acres in the 48 States.

Water Use

Projections were made of the regional water requirements for public supplies, self-supplied industrial uses, and irrigation. In 1960, almost 266 billion gallons of water per day were withdrawn from streams and ground water supplies for these uses. It is anticipated that requirements will increase by more than 60 percent between 1960 and 1980, and by more than 150 percent between 1960 and 2000 (table 66).

Water Requirements for Public Supplies

Water used for public supplies includes all water pumped into public water supply systems. This water is used for municipal, domestic, and commercial and industrial purposes. Industrial self-supplied water includes all industrial water used which is not supplied by public water systems. Irrigation water includes all water used in the production of agricultural crops, including water for supplemental irrigation.

In projecting regional water requirements, intensive use was made of cross-sectional data for 1960 provided by the U.S. Geological Survey. Regression equations were developed to describe and explain industrial water supplied from public supplies and the consumption of public supplied water, i.e., water not returned to streams or ground water storage. With the exception of these two categories of water use, all projections of water requirements were based on relationships determined by other studies.

The total water withdrawals for public supplies are projected to be 34.8 billion gallons per day in 1980, and 50.3 billion per day by 2000. Of these amounts, only 3.7 billion gallons per day in 1980, and 4.3 billion gallons per day in 2000, will be consumed. The remainder will be available for reuse.

In general, the water requirements for public supplies in a given region are determined by the regional population served by public supplies, the degree of regional urbanization, and the structure of regional industry. Each of these variables was analyzed and projected for each of the regions considered in this study.

Water Requirements for Self-Supported Industry

Although some industrial water is provided from public supplies, by far the greatest part of industrial water (more than 90 percent) is self-supplied by users. It is not anticipated that any significantly greater proportion of industrial water will be supplied by public supplies in the future. The projections for self-supplied water for 1980 and 2000 are 276.4 and 445.2 billion gallons per day, respectively.

Water Requirements for Irrigation

The current use of water in the United States for irrigation accounts for approximately 40 percent of total water withdrawals (excluding water power), and 80 percent of the annual consumption of water. Taking account of Federal water development projects now approved or on record awaiting authorization to proceed prior to 1980, and assuming a continuation of past trends in Federal and private developments from 1980 to 2000, it is projected that 50.5 million acres will be under irrigation in 1980 and 53.3 million acres in 2000.

Withdrawals of water for irrigation purposes in 1980 and 2000 are projected to be approximately 130 and 135 billion gallons per day, respectively, in 1980 and 2000. Of these amounts, 39 billion gallons per day will be discharged and available for reuse in 1980, and 41 billion gallons per day will be discharged in 2000.

Appendixes

The Appendixes to each chapter present the detailed methods used in projecting consumption and the supporting historical data used to establish trends.

CHAPTER I

INTRODUCTION

The objective of this study is to provide projections to 1980 and 2000 for national and regional populations, economic characteristics, outdoor recreational activities, land occupancy, and the consumption of commodities producible on the public lands of the United States. The purpose of these projections is to provide a framework within which the effects of alternative public land policies can be tested and evaluated.

Scope of Study

The aggregates and commodities considered were determined by the requirements of the Public Land Law Review Commission. The aggregates selected are those which are measures of the most important characteristics of the economy of the United States. Projections of these aggregates not only provide a basis for estimating general standards and patterns of life in the United States in 1980 and 2000, but are also the determinants of the consumption of commodities.

The commodities selected for study are those which are producible on the public lands of the United States. It should be noted, however, that although these commodities are all producible on the public lands, for commodities such as wheat and cotton there is little or no current public lands production.

National and Regional Projections

Although both national and regional projections were made for population and most economic aggregates, regional projections were made only for those commodities which are mainly consumed in the regions in which they are produced. Because the consumption of these commodities is related to a regional resource base, the requirements for resources related to these commodities are regional rather than national in scope.

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For commodities which were not considered on a regional basis, regional consumption is not related to regional production. These commodities are usually embodied in finished goods which are widely distributed throughout the United States. Further, the consumption in any given region is usually small relative to national consumption. For these reasons, the requirements for resources related to these commodities are national rather than regional. Although the growth of population and increased economic activity in any given region may eventually provide large regional markets for these commodities and for regional resources, the lack of historical data generally precluded the possibility of making realistic projections of future regional consumption.

Outdoor recreational activities and land occupancy requirements are dependent on the physical and economic characteristics of the regions in which they occur. Thus, regional projections were made for both.

For the purpose of this study, regions of the United States are defined to be the three census regions of the eastern United States and the 11 contiguous western States. Even though national projections of aggregates, activities, and commodity consumption include Alaska and Hawaii, no regional projections were made for these States. Following is a list of the regions and States considered in the study:

Northeast
North Central
South
West:
  Utah
  Oregon
  Montana
  Idaho
  Wyoming
  Nevada
  California
  Colorado
  New Mexico
  Arizona
  Washington

Projections of Aggregates

As indicated above, aggregates were projected to provide indicators of the standards and patterns of life in the United States in 1980 and 2000, and to provide a basis for projecting the consumption of specific commodities. Projections were made for the following aggregates:

1. Population. Projections were made of national and regional populations of the United States. In addition, national and regional projections were also made for male and female population components, urban and rural populations, and broad population age distributions.

2. Labor Force and Employment. National and regional projections were made for the labor force, male and female labor force components, employment, and unemployment.

3. Productivity. National and regional projections were made of productivity measured in terms of product per employed person.

4. Gross National Product (GNP). In addition to projections of GNP, projections were made for government purchases of goods and services (G), personal consumption expenditures (PCE), gross private domestic investment (GPDI), personal income (PY), personal disposable income (PDY), and imports (M) and exports (X).

5. Index of Industrial Production. The Federal Reserve Board index of national industrial production, and important components of the index were projected. Projections of regional indexes were not possible because comparable indexes do not exist for any of the regions considered in this study.

6. Gross Product Originating (GPO). As regional equivalents of national GNP, projections were made for the GPO of each region considered in the study, the products of regional GPO component industrial sectors (including manufacturing, agriculture, and "all other"), and regional personal incomes.

Projections of Consumption

Only national projections were made for commodities and activities, with the exception of water consumption, electricity generation, common variety minerals consumption (sand, gravel, etc.), land occupancy requirements, and outdoor recreational activities. Both national and regional projections were made for electricity generation, common variety minerals, and recreation. In addition to national and regional projections, export projections were made for those commodities which flow in international trade.

Following is a list of the specific commodities and activities projected:

(1) Agricultural crops (including feed grains, wheat, soybeans, and cotton).

(2) Forage (major products for which forage is used, in animal equivalents).

(3) Timber (including softwood and hardwood sawlogs, veneer logs, and pulpwood).

(4) Nonfuel minerals (including major metals -- iron and steel, aluminum, copper, lead, and zinc; minor metals -- manganese, mercury, nickel, tungsten, diatomite, molybdenum, vanadium, sand and gravel; and chemicals and fertilizers -- sulfur, potash, and phosphates).

(5) Energy and mineral fuels (including electricity generation, oil, gas, coal, oil shale, and uranium).

(6) Water (including water for municipal, industrial and irrigation purposes).

(7) Land occupancy (including requirements for transportation, other rights-of-way, urban and industrial uses, military uses, scientific uses, and second homesites).

(8) Outdoor recreation (including recreation visits and visitor days to National and State parks, National forests, and wildlife refuges by summer day use, summer overnight use, and use for winter sports).

(9) Fish and wildlife (including number of hunters and activity days for big game, small game, migratory waterfowl, and fresh and salt water fish).

General Method

All of the projections are internally consistent in the sense that projections of the consumption of basic commodities are consistent with projections of the consumption of end products in which the commodities may be embodied. Further, the projections of the consumption of individual commodities are consistent with the projections of the consumption of all other commodities and the projections of aggregates. The requirements for consistency of the projections did not demand the use of a single method in making the projections, however. Because of differences in the availability and forms of official U.S. Government data and projections, and other data and projections approved for use by the Public Land Law Review Commission, a variety of projecting techniques were employed.

Use of Other Studies

Because of time and budget constraints, it was necessary to rely to the greatest degree possible on the projections and data provided by other studies. One source of information considered as basic to the current study was a 1963 study conducted by Resources for the Future, Inc. Although this study did not include projections on a regional basis, it provided an invaluable source for the projections of consumption of some of the commodities for which only national projections were made, particularly mineral fuels.

A second important source of information was the National Planning Association. The continuing studies conducted by NPA provided estimates for various aggregates, particularly regional gross product originating, which are not available elsewhere.

For projections of population, projections by the U.S. Bureau of the Census were used. These projections were then combined with the results of studies of the Bureau of Labor Statistics, the Bureau of Public Roads, and other Government agencies to obtain estimates of such variables as the labor force and urban and rural populations.

The precise manner in which these and other studies were used as bases for the projections made in this study is explained in detail in the subsequent chapters and appendixes.

The literature cited in the chapters is presented in a bibliography at the end of each chapter.

The Projection of Aggregates

The projections of aggregates are based on Bureau of the Census population projections, judgment estimates of future GNP growth rates, and historical relationships (1948-65) of population, GNP, and various other aggregates. Low, medium, and high projections are provided for national and regional populations and each of the aggregates projected.

(1) The medium projection reflects a judgment as to the "most likely" values of projected variables in the years 1980 and 2000. For population, the medium projection was selected from the range provided by the Bureau of the Census. The medium projection for GNP was selected in consultation with the staff of the Public Land Law Review Commission. Medium projections for other aggregates are considered to be their "most likely" values, given the medium projections of population and GNP.

(2) High and low projections of population and GNP were selected in the same manner as the medium projections. For other aggregates, the high and low projections were based on considerations of the implications of possible variations in the growth of population and GNP.

The Projection of Consumption

The projections of commodity consumption, outdoor recreational activities, and land occupancy requirements are related to projections of national and regional production, population, and other aggregates. Generally, the consumption of commodities was based on the demand for the major products for which the commodities are used as inputs. Suitable adjustments were made to account for possible technological changes and commodity substitutions. Exceptions to this procedure were made whenever it appeared feasible to make direct projections of commodity consumption because a substantial direct final demand for the commodity existed, or because the nature of the commodity allowed a direct relationship to be established between consumption and the values of aggregates.

Most consumption projections in the study explicitly incorporate consumption and other trends observed for the period 1948-65. In a few instances, survey data were not sufficient to allow the construction of time series, particularly for water and recreational activities.

While efforts were made to update all relevant RFF series on consumption to 1965, consultation with members of the RFF staff revealed that the nature of much of the current data made it impossible to reconcile current data with all of the series. In instances where it was not possible to update RFF series, new series were constructed for the period 1948-65.

As in the projections of the aggregates, three projections (low, medium, and high) were made for each class of consumption, and these projections correspond to the range of aggregate projections. It should be noted, however, that high consumption projections are not necessarily the end result of the projected highs of all aggregates, and the low projections are not necessarily the end result of the projected lows (e.g., high personal income may result in high projections of electricity consumption for household spaceheat and low projections for coal used for this purpose).

Basic Assumptions

Because the projections of this study are based on recent trends in the major factors that affect the economy of the United States, it has been necessary to assume that certain trends will continue into the future. For the most part, therefore, unless otherwise stated in the text of this report, recent trends in the following are assumed to persist to 1980 and 2000:

(1) U.S. consumption needs and preferences.

(2) Changes in the relative prices of competing commodities.

(3) Federal policies regarding economic growth, economic stability, economic equity, regional development, and foreign policy.

(4) Military commitments and mobilization for defense.

Unless otherwise stated, Robert R. Nathan Associates, Inc., assumes full responsibility for all assumptions and analyses leading to the projections in this study.

CHAPTER II

NATIONAL AND REGIONAL AGGREGATES

Projections of population, labor force, employment, productivity, output, industrial production, and personal income for the Nation and for each of the regions for which commodity projections have been made are presented in this chapter.

Population

Projections of National Population

The Bureau of the Census has prepared four alternative sets of U.S. population projections, based on four sets of alternative assumptions, for the years 1980 and 2000 [8].1/ These projections and their underlying assumptions were studied to select the Census projections, or interpolations between projections, most likely to reflect the demographic changes which will occur in the United States between 1965 and 1980, and 2000. The projections selected were then designated as the medium population projections for this study. The Census projections were also studied to determine the most plausible high and low projections for the target years.

The four sets of Census projections are alike in their assumptions of death rate and net immigration. The important differences in the projections are the assumptions about fertility which lead to substantial differences in the projected population. Census Bureau fertility rates are defined in terms of the total number of children per 1,000 women in their lifetimes. The fertility assumptions underlying the four alternative projections were summarized by the Bureau as follows:

> The projected average number of children per 1,000 women at the end of childbearing ("average size of

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1/ Figures in brackets refer to the Literature Cited at the end of each chapter.

completed family")...would gradually move towards the following 'terminal' levels:

Series A, 3,350, approximately the level of the calendar-year total fertility rate in 1963 (i.e., the synthetic rate based entirely on the experience of 1963).

Series B, 3,100, about the level of the average of the calendar-year rates in 1964 and 1965.

Series C, 2,775, corresponding to the calendar-year rate of 1966.

Series D, 2,450, last observed as a calendar-year rate in the early forties [8].

Medium Projections of National Population

The statistical data and various human factors indicate that the most likely projections of the United States population in 1980 and 2000 are based on the Census Bureau Series C fertility assumptions. These assumptions result in projections of total population of 235 million in 1980 and 308 million in the year 2000 (table 1). The current fertility rate, as indicated by data for the first three quarters of 1967, is somewhat below the rate assumed by the Series C projections. Because the current fertility rate appears to be abnormally low given the experience of recent decades, the rate over the coming years will probably average slightly higher than the current rate, although lower than the 1965 rate and much lower than the rates in the 18 years preceding 1965.

High and Low Projections of National Population

The Census Bureau high projections of population are based on the Series A fertility assumption. Under this assumption, the average number of children born per 1,000 women will gradually move toward a level of 3,350. Such a high rate has not been achieved by any cohort of women since those born in the early 1880's [15, p.4]. Whereas the cohorts born in 1935 and 1936 are passing through their most fecund years at the postwar peak of birth rates and may achieve a fertility rate approaching the Series A projection rate, these seem to be special cases and not likely to become the norm for the 1965-80 or the 1965-2000 periods. For these reasons, our high population projections for 1980 and 2000 are based on a fertility rate higher than the Series B rate, but lower than the Series A rate, implying an average number of 3,225 children born per 1,000 women (table 1).

The Series D Census Bureau projections were used to derive the low projections in this study. Although the total fertility rate of 2,450 on which the Series D figures were based was not the lowest which this country has experienced, the lower rates that occurred between 1931 and 1941 were abnormally low because of economic factors resulting from the great depression, and are not likely to be typical of the future (table 1).[2]

Table 1. United States Population, 1965 and Projected 1980 and 2000

(in millions)

Level	1965 (Actual)	1980	2000
Low................		227.7	282.6
Medium.............	194.6	235.2	307.8
High...............		246.9	348.7

Source: 1965 data from [7].

Projections of Regional Populations

Regional population projections must take into account not only fertility assumptions, but also internal migration assumptions. The most recent publications of The Bureau of the Census, Population Estimates [7, 9], project four separate series based upon two alternative interstate migration assumptions and two fertility assumptions. The migration assumptions are:

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[2] Projections presented in the tables in this report are by Robert R. Nathan Associates, unless otherwise noted.

I. Migration rates will continue within the ranges observed between 1955 and 1965, or

II. The population movements noted between 1955 and 1965 will gradually diminish, leading to a projection of no net migration among States in 50 years.

Migration assumption II seems to be the more realistic of the two, and it was therefore used as a basis for projecting regional population in 1980 and 2000. Given the historical tendency toward the equalization of economic opportunities and other social and economic differentials among the States, then (apart from the effects of new influences in the future that are not predictable) some long-run equilibrium in net migration can be envisioned.[3]

The regional projections issued by the Census Bureau extend only to 1985. To arrive at regional projections for 2000, the trend of each region's population, expressed as a percentage of the national population, was traced from 1950 (actual) through 1985 (as projected by the Census Bureau), and the trends thus derived were projected to 2000 (table 2). The figures for 1980 were determined by interpolation.

Projections of Urban and Rural Populations

In addition to the projections of national and regional populations for 1980 and 2000, projections were also made of the distribution of the U.S. population between urban and rural areas. For the Nation as a whole, it is projected that the proportion of the population which is urban will have increased from 69.6 percent in 1960[4] to approximately 77 percent in 1980, and 82 percent in 2000 (table 3). These percentages reflect the expectation that the rural population, which was 54.1 million in 1960, will change little over the projection period (table 4).

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[3] For detailed explanation of Series II assumptions, see [9].

[4] Used as base year because data on the urban/rural population distribution are not available for 1965.

Table 2. United States Population, by Regions, 1965 and Projected 1980 and 2000
(in thousands)

Region	1965 (Estimated)	1980			2000		
		Low	Medium	High	Low	Medium	High
United States[a]...	194,592	227,700	235,200	246,900	282,600	307,800	348,700
Northeast.......	47,617	53,730	55,500	58,270	64,000	69,620	78,870
North Central...	54,089	60,060	62,040	65,130	72,730	79,130	86,640
South...........	60,106	71,030	73,370	77,020	88,510	96,300	109,090
West:[a]	32,780	42,880	44,290	46,480	57,360	62,750	74,100
Montana.......	703	770	800	840	960	1,040	1,180
Idaho.........	693	770	800	840	960	1,040	1,180
Wyoming.......	330	360	370	390	450	490	560
Colorado......	1,949	2,400	2,480	2,610	3,070	3,340	3,790
New Mexico....	1,014	1,280	1,320	1,390	1,890	2,050	2,330
Arizona.......	1,575	2,240	2,320	2,430	3,330	3,650	4,130
Utah..........	994	1,250	1,290	1,360	1,780	1,930	2,190
Nevada........	434	640	660	700	790	860	970
Washington....	2,973	3,380	3,490	3,660	4,260	4,630	5,240
Oregon........	1,938	2,260	2,330	2,450	2,820	3,070	3,470
California....	18,403	25,340	26,180	27,480	34,800	37,860	42,890

30 976

[a] Includes Alaska and Hawaii.

Source: 1965 data from [9].

Table 3. Urban Population, 1960 and Projected 1980 and 2000

(in thousands)

Region	1960 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
United States[a]...	124,698	174,095	179,839	188,801	229,873	250,095	280,895
Northeast.......	35,840	34,274	45,732	48,014	54,080	58,829	66,645
North Central...	35,481	45,345	46,840	49,173	58,839	64,016	70,092
South...........	32,160	49,792	51,432	53,991	68,241	74,247	84,108
West:[a]	21,217	34,684	35,835	37,623	48,713	53,003	60,050
Montana.......	338	462	480	504	643	697	791
Idaho.........	317	440	457	480	601	651	739
Wyoming.......	187	238	245	258	338	368	421
Colorado......	1,293	2,042	2,110	2,211	2,760	3,003	3,407
New Mexico....	627	1,065	1,098	1,156	1,710	1,855	2,109
Arizona.......	971	1,931	2,000	2,095	2,954	3,238	3,663
Utah..........	667	1,026	1,059	1,117	1,515	1,642	1,864
Nevada........	201	543	560	594	723	787	888
Washington....	1,943	2,562	2,645	2,774	3,489	3,792	4,292
Oregon........	1,100	1,620	1,671	1,757	2,208	2,404	2,717
California....	13,573	22,755	23,510	24,677	31,772	34,566	39,159

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[a] Excludes Alaksa and Hawaii.

Source: 1960 data from [6].

Table 4. National Urban and Rural Populations, 1960 and Projected 1980 and 2000[a]

(in millions)

Area	1960 (Actual)	1980	2000
Urban:			
Low...........	--	175.0	231.1
Medium........	125.3	180.8	251.4
High..........	--	189.8	284.8
Rural:			
Low...........	--	51.7	50.7
Medium........	54.1	53.4	55.2
High..........	--	56.0	62.5

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[a] Sum of urban and rual populations projections differ from projections of total national population because national population projections include armed forces overseas.

Source: 1960 data from [6].

The projections of the national and regional urban and rural populations are based on Bureau of Public Roads (BPR) projections, the only readily available long-term projections.[5] In the BPR study, regional and national urban and rural populations were projected for the years 1975 and 1985. Interpolations were made to determine the figures for 1980, and extrapolations from 1985 were made to determine the projections for 2000.

Labor Force and Employment

National Projections

Projections of the national labor force and of the level of employment are based on the population projections and Bureau of Labor Statistics (BLS) projections of labor force participation rates for age and sex groups [14]. Employment rates were determined on the basis of probable future national economic policies.

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[5] Unpublished estimates of urban population in 1975 and 1985, U.S. Bureau of Public Roads, 1965.

Labor Force

For the national medium labor force projection for 1980, the labor force participation rates projected by the BLS were applied to the appropriate age (16 years and over) and sex groups. Since these cohorts of the 1980 population have already been born and are part of the current population, projections were determined only by the range of possible labor force participation rates.

The range of possible labor force participation rates used reflected different assumptions about age of entry into and retirement from the labor force. The low projection, for instance, assumed that greater national affluence will result in delayed entry into the labor force as greater numbers of young people seek more education, and that retirements from the labor force will occur at younger ages. Labor force projections for 2000 were based on BLS labor force participation rates extrapolated from 1980 and the projections of population for 2000 (table 5).

Employment

For national employment projections, employment was assumed to be 96 percent of the labor force for the medium projection, and 95.5 percent and 97 percent, respectively, for the low and high projections in both 1980 and 2000 (table 5). These projections reflect an assumption that there will be sufficient demand for the greatly increased amount of goods and services that such volumes of employment would produce.

Our assumption that an adequate expansion in demand will occur appears justified. It is, in effect, an implicit assumption that wise economic management can regulate the national level of demand so as to make use of available supplies. To the extent that private demand is inadequate, governmental measures to take up the slack can be expected. The Government will have strong incentives to take such measures, since large-scale unemployment will be politically untenable as well as unnecessary, given the available economic tools.

Table 5. National Labor Force and Employment (Including Armed Forces), 1965 and Projected 1980 and 2000

Item	1965 (Actual)	1980	2000
Population 16 years and over (millions)			
Low	--	166.6	206.1
Medium	131.2	166.6	216.5
High	--	166.6	232.0
Labor force participation rate (percent of population 16 and over)			
Low	--	56.1	55.1
Medium	58.8	60.5	62.3
High	--	60.9	63.1
Labor Force (millions)			
Low	--	93.4	113.6
Medium	77.2	100.7	134.9
High	--	101.4	146.5
Employment (millions)			
Low	--	89.2	108.5
Medium	73.8	96.7	129.5
High	--	98.4	142.1
Annual growth rate in employment from 1966 level (percent)			
Low	--	1.15	1.06
Medium	--	1.73	1.58
High	--	1.87	1.86

Source: 1965 data from [11].

One of the areas in which human knowledge has made the greatest strides in recent decades is the field of national economic management. Further progress in this field between now and 2000 can be expected. In the early thirties, little was known of macroeconomic processes and how to influence and control them. Since that time, there has occurred not only the expansion of technical economic knowledge, but a most impressive expansion of the degree to which such knowledge is understood and acted upon by the Government and the public at large. The manner in which growth and stability at high levels have been generally maintained since 1961 is a demonstration of this understanding.

One prediction that can be made with an especially high degree of confidence is that, in respect to the advances of knowledge that have already occurred, their application to the practical management of economic processes will become increasingly effective in the coming decades.

With this progress in macroeconomic management, it has become clear that an important factor still remaining, which could limit economic growth and the degree to which full employment can be attained, is the extent to which individual Americans lack working skills. Many people are not equipped to fill jobs and participate in a full-employment economy, but in the last few years, this problem and the need for public action to deal with it have been increasingly recognized. Public education and training programs have been initiated, and it seems certain that an expansion of such training activities will occur. As a result of progress in equipping more Americans to participate in the general labor market, it will be possible to achieve lower levels of unemployment in the future. Hence, it is considered likely that the projected low levels of unemployment will be attained and maintained.

Undoubtedly, fluctuations in employment will still occur from year to year, but the relatively high levels of employment assumed above seem reasonable and may be expected to serve as trend values around which the year-to-year fluctuations will take place. Thus, it is anticipated that high, medium, and low levels of employment will be determined mainly by population size and labor participation rates, rather than by fluctuations in the demand for labor. The medium unemployment rate for both 1980 and 2000 is projected at 4.0 percent, the low rate is 3.0 percent, and the high rate is 4.5 percent.

Although it does not appear likely that the high unemployment rate will exceed the rate projected, to determine the effects of a higher rate, additional calculations were made on the assumption that unemployment might average as high as 5.0 percent. The annual rates of growth in employment from the 1966 level, based on this assumption, would be changed from 1.15 to 1.11 percent for the period to 1980, and from 1.06 to 1.04 percent between 1980 and 2000. The full effects of this alternative high unemployment projection on gross national product (GNP) are included in the general discussion of GNP.

Regional Projections

Regional labor force projections are based on the population projections and the 1980 regional labor force participation rates projected for States by the Bureau of Labor Statistics [13], as shown in table 6. The differential between the average participation rate for each region and the U.S. average was calculated for 1980 (regional rates as percentages of national rates). These regional differentials were applied to the high, medium, and low projections of the national labor force participation rate to arrive at high, medium, and low regional participation rates for 1980.

In projecting the regional labor force for 2000, the trend of each regional participation rate as a percentage of the national participation rate was extrapolated from 1980 to 2000. The portion of the regional populations of working age (16 years and over) was also projected, using the national ratios of population of working age to total population. These ratios were then applied to the projected regional total populations. The regional participation rates, determined from the national rates, were, in turn, applied to the regional populations of working age.

Regional employment for 1980 was projected on the basis of historical employment-to-unemployment ratios in each region (table 7). These ratios were compared with national ratios for 1950 and 1960. The trends in the ratios, indicating a tendency toward narrowing regional differentials, were then projected to 1980. Projections of unemployment in each region were made by applying the projected unemployment rates to the projected regional labor force (table 8).

For the year 2000, national average unemployment rates were assumed for each region (table 7). We think that this

Table 6. Regional Labor Force, 1960 and Projected 1980 and 2000
(in thousands)

Region	1960 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
United States[a]...	69,880	93,430	100,770	101,400	113,120	134,080	145,550
Northeast.......	18,250	22,360	24,070	24,210	24,570	29,130	31,650
North Central...	20,050	25,030	26,930	27,130	29,930	35,490	38,470
South..........	20,400	28,510	30,680	30,900	35,520	42,130	45,740
West:a/	11,180	17,530	19,090	19,160	23,100	27,330	29,690
Montana.......	254	320	340	350	400	470	510
Idaho.........	251	340	370	370	420	500	540
Wyoming.......	130	160	170	170	190	220	240
Colorado......	681	1,040	1,130	1,130	1,340	1,580	1,720
New Mexico....	328	490	530	530	790	930	1,010
Arizona.......	471	880	950	960	1,400	1,660	1,800
Utah..........	319	520	570	570	780	920	1,000
Nevada........	127	280	310	310	320	380	410
Washington....	1,125	1,440	1,560	1,570	1,780	2,110	2,290
Oregon........	685	930	1,000	1,010	1,100	1,300	1,410
California....	6,450	10,800	11,650	11,740	14,020	16,590	18,040

a/ Includes Alaska and Hawaii.

Source: 1960 data from [13].

Table 7. Regional Civilian Unemployment Rates as Percentages of National Unemployment Rates, Actual 1950 and 1960, and Projected 1980 and 2000

Region	1950	1960	1980	2000
United States[a].	100.0	100.0	100.0	100.0
Northeast.....	120.8	107.7	100.0	100.0
North Central.	79.7	93.7	100.0	100.0
South.........	67.2	96.7	100.0	100.0
West:a/				
Montana.....	106.3	133.9	106.3	100.0
Idaho.......	114.6	110.1	101.1	100.0
Wyoming.....	89.6	99.4	100.0	100.0
Colorado....	87.5	76.6	87.5	100.0
New Mexico..	125.0	116.6	100.0	100.0
Arizona.....	158.3	103.5	100.0	100.0
Utah........	108.3	79.5	100.0	100.0
Nevada......	139.6	121.2	100.0	100.0
Washington..	139.6	129.9	110.5	100.0
Oregon......	135.4	117.5	100.0	100.0
California..	164.6	119.0	100.0	100.0

a/ Includes Alaska and Hawaii.

Source: 1950 data from [5, table 119].
1960 data from [6, table 119].

Table 8. Regional Employment, 1960 and Projected 1980 and 2000

(in thousands)

Region	1960[a] (Actual)	1980[b] Low[c]	1980[b] Medium[d]	1980[b] High[e]	2000 Low[c]	2000 Medium[d]	2000 High[e]
United States.....	66,373	89,230	96,740	98,390	108,030	128,720	141,180
Northeast.......	17,322	21,360	23,100	23,480	23,460	27,960	30,700
North Central...	19,087	23,900	25,850	26,310	28,580	34,070	37,320
South...........	19,422	27,230	29,450	29,970	33,920	40,440	44,370
West:[a]........	10,542	16,740	18,340	18,630	22,070	26,250	28,790
Montana.......	238	300	330	340	380	450	490
Idaho.........	237	320	350	360	400	480	520
Wyoming.......	123	150	160	170	180	210	230
Colorado......	655	1,000	1,090	1,110	1,280	1,520	1,670
New Mexico....	310	470	510	510	750	890	980
Arizona.......	447	840	910	930	1,340	1,590	1,750
Utah..........	306	500	540	550	740	880	970
Nevada........	120	270	300	300	310	360	400
Washington....	1,054	1,370	1,490	1,520	1,700	2,030	2,220
Oregon........	644	890	960	980	1,050	1,250	1,370
California....	6,062	10,310	11,180	11,390	13,390	15,930	17,500

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[a] 1965 total regional employment figures are not available; the 1960 regional employment equals regional figures for civilian employment plus the Armed Forces and Alaska and Hawaii.

[b] For States with ratios in the third column of table 7 differing from 100.0, percentages of unemployment for the 1980 high, medium, and low projections would differ in the same proportions from 4.5, 4.0, and 3.0 percent, respectively.

[c] Low labor force less high unemployment (4.5 percent).

[d] Medium labor force less medium unemployment (4.0 percent).

[e] High labor force less low unemployment (3.0 percent).

Source: 1960 data from [6, table 119].

assumption is justified, given the national emphasis on the problem of regional economic differentials. It can be anticipated that many of the problems which contribute to regional differentials in jobs and income will be solved by 2000. National policies and programs will be designed to prevent any region from having regional unemployment rates unduly in excess of national average unemployment rates.

Productivity

The national projections of productivity are expressed in terms of gross national product (GNP), in 1958 dollars per employed person. Various past trends and other influences that affect the future rate of growth in productivity were studied, and other projections were examined, particularly the studies of the National Planning Association [3]. In addition, such factors as technological change, trends in the length of the workweek, and changes in the relative importance of the various industrial sectors were considered.

The NPA study projected a rate of increase of 2.6 percent per year in output per employed person. Using 1948-65 as the period of comparison, the NPA study considered factors that could cause future rates of growth to differ from the 1948-65 rate. This study concluded that the factors of increase and decrease will approximately counterbalance each other, and that the 2.6-percent rate is applicable for both periods, 1965 to 1980 and 1965 to 2000.

Upon consideration of the most important factors affecting future productivity, we concluded that the NPA projections are reasonable. The resulting medium projections of GNP per employed person are $12,300 for 1980 and $20,400 for 2000. For the high and low projections, annual productivity increases of 2.8 and 2.25 percent, respectively, were assumed (table 9).

Gross National Product

Projections of GNP are based on projected rates of growth in output per employed person and in total employment. Medium projections of the rate of growth of GNP for both 1980 and 2000 are based on the medium projections of both the rate of growth of GNP (in 1958 constant dollars) per employed person and the rate of growth in the number employed.

Table 9. Gross National Product per Employed Person, 1965 and Projected 1980 and 2000

(in 1958 dollars)

Level	Average annual increase, 1965-2000 (percent)	1965	1980	2000
Low..........	2.25	--	11,700	18,200
Medium........	2.6	8,360	12,300	20,400
High..........	2.8	--	12,700	22,000

In arriving at high and low projections for GNP, the process was slightly more complicated. For example, for the low projection, the GNP might be below the medium projection either because of low labor force and employment or because of a low rate of growth in output per employed person. However, if the increase in number of persons employed is low, i.e., less than indicated by the medium population and employment projections, this could be expected to lead to a higher level of investment per employed person, given the assumption that employment will be determined by population size and labor force participation rates rather than by fluctuations in the demand for labor. It does not seem likely, therefore, that low employment would be accompanied by a low level of productivity per employed person.

Two possibilities were considered in making the low projections: (1) There might be low employment, in which case productivity per person at least at the medium level could be expected; and (2) productivity might be low, with employment at least at the medium level. Since either situation is possible and plausible, calculations were made using both assumptions; the lower of the calculations was taken as the low projection for GNP (table 10).

For the high GNP projections, calculations were also based on two possibilities: (1) There might be high employment, in which case productivity per employed person would not be higher than the medium projection, and (2) productivity might be high, with employment not higher than the medium employment projection. The higher of these calculations was used as the high projection for GNP (table 10).

Table 10. U.S. Gross National Product Growth Rates and Values, 1965 and Projected 1980 and 2000

Item	1965 (Actual)	1980	2000
Rates of growth in GNP[a/] (percent)			
Low..................		3.8	3.7
Medium...............		4.4	4.2
High.................		4.6	4.5
GNP (billions of 1958 dollars)			
Low..................		1,079	2,200
Medium...............	617	1,176	2,603
High.................		1,211	2,878

[a/] Compound annual rate from 1965.

An additional calculation of GNP was made based on an assumption that the rate of unemployment might average as high as 5 percent, instead of the 4.5 percent assumed as the high rate in this study. For the year 2000, the change in the average annual rate of increase in GNP resulting from the higher rate of unemployment would be a few one-hundredths of 1 percent; rounded to tenths, the low annual rate of 3.7 percent would be unchanged. For 1980, the low annual rate of 3.8 percent would be reduced to 3.74, rounded to 3.7. The projected low GNP figure of $1,079 billion for 1980 would be reduced by approximately $10 billion.

Components of GNP

Estimates were made of GNP components, including personal consumption expenditures, gross private domestic investment, government purchases of goods and services, exports and imports, and net exports. Projections were also made for personal disposable income (table 11).

For 1980, the ratios of the components to GNP as projected to 1977 by NPA were used as a basis for the projections [3]. The medium 1980 projections of the components

Table 11. Gross National Product Components and Personal Disposable Income, 1965 and Projected 1980 and 2000

Item	Percent of GNP			1965 (Actual)	1980			2000		
	1965 (Actual)	1980	2000		Low	Medium	High	Low	Medium	High
				-----------------	------- Billion	1958 dollars	----------	-----------	-----------	-----------
Gross national product				617	1,079	1,176	1,211	2,200	2,603	2,878
Personal consumption expenditures....	64.6	65.7	61.7	398	709	773	795	1,357	1,606	1,776
Gross private domestic investment....	15.8	16.1	16.0	98	174	189	195	351	416	460
Government purchases of goods & services.	18.5	17.5	21.8	114	189	206	212	280	567	628
Exports...	6.1	6.5	7.4	38	70	76	79	163	193	213
Imports...	5.1	5.8	6.9	32	63	68	70	152	180	199
Net exports...	1.0	.7	.5	6	8	8	9	11	13	14
Personal disposable income.....	73.1	73.0	68.6	451	788	859	884	1,508	1,784	1,973

Source: 1965 data from [12].

were determined by multiplying the projected medium GNP figure by the ratios of the respective components to GNP. Similarly, the high and low 1980 projections of the components were based on the projected high and low GNP figures (table 11).

In extrapolating these projections to the year 2000, the ratios of personal consumption expenditures and government expenditures to GNP were adjusted to reflect the prospect of increased government financing of services (table 11).

Personal Disposable Income Per Capita

In projecting personal disposable income per capita, there were several ways in which the three distinct population projections could be combined with the three projections of personal disposable income (PDY). Given the definition of the medium projections, the medium projections of PDY per capita for 1980 and 2000 are, of course, the medium total PDY divided by the medium population (table 12).

Table 12. National Personal Disposable Income Per Capita, 1965 and Projected 1980 and 2000

(1958 dollars)

Year and level	Personal disposable income (billion)	Population divisor (million)	Personal disposable income (per capita)
1965: (actual).....	451	194.6	2,320
1980: Low..........	788	246.9	3,190
Medium.......	859	235.2	3,650
High.........	884	227.7	3,880
2000: Low..........	1,508	307.8	4,900
Medium.......	1,784	307.8	5,800
High.........	1,973	307.8	6,410

Source: 1965 data from [12].

As a means of projecting the high and the low per capita for 1980, the high PDY was divided by the low population projection, and the low PDY was divided by the high population projection. This seemed appropriate because the number of people of working age in 1980, a determinant of PDY, is already determined by the age distribution of the present population and will not be affected by population changes resulting from births in the future.

For 2000, however, such an approach would not be appropriate because, using high income per capita as an example, high PDY could not be achieved if the population and labor force were at their low levels. The highest plausible value of PDY per capita is the high PDY divided by the medium population (since dividing by the high population would give a lower PDY per capita). Similarly, the high population projection is not considered to be consistent with the low PDY projections. The lowest probable value of PDY per capita is the low projection of PDY divided by the medium projection of population (table 12).

Industrial Production

As a measure of industrial production in 1980 and 2000, the Federal Reserve Board (FRB) index of industrial production [1, 2] was projected as well as some of the principal components of the index. In making these projections, use was made of the GNP projections and projected relationships between the levels of industrial production and GNP. A series of ratios, or coefficients, between the index and related variables was calculated for each of the FBR indexes (both the overall index and each component). The related variables selected for this purpose were GNP and its components.

For each series of coefficients, the historical trends for the period 1956-65 were studied,[6] and appropriate values for the coefficients were projected for 1980 and 2000. The projected values of each FRB component index were obtained by multiplying (1) the relevant figures by related variables, as projected for 1980 and 2000, by (2) the projected ratios of the industrial production index to related variables (table 13).

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[6] Data for the years 1948-55 were also studied. Because of postwar dislocations, the ratios in those years showed such erratic fluctuations that they were not used in the projections.

Table 13. Federal Reserve Board Indexes of Industrial Production, 1965 and Projected 1980 and 2000

(1957-59 = 100)

Industrial production index	1965 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Total index......	143	282	308	317	511	605	669
Consumer goods..	140	245	267	275	460	545	602
Equipment......	147	290	316	325	524	620	686
Materials......	144	284	310	319	514	608	673
Total index......	143	282	308	317	511	605	669
Manufacturing..	145	273	297	306	506	599	662
Durable......	148	284	309	318	517	612	677
Nondurable...	141	258	282	290	492	582	644
Mining........	115	149	163	168	305	360	398
Utilities......	161	385	420	432	1066	1,261	1,395

Source: 1965 data from [1, 2, 3].

Of particular importance in projecting the indexes are the possible shifts in the relative sizes of the various economic sectors over the projection period, including an anticipated growth in the service sectors relative to consumer goods production.

Gross Product Originating

Projections to 1980 and 2000 were made for the Gross Product Originating (GPO) in each region. Gross Product Originating is computed by considering the value added to the product of each of the sectors of the economy at each stage of processing. Conceptually, the sum of regional GPO figures is equal to GNP; however, because of data problems, slight variations between GPO and GNP do exist. National and regional projections were also made in each of three main industrial sectors: agriculture, manufacturing, and all other sectors aggregated (tables 14-18).

Table 14. Gross Product Originating in Industrial Sectors as Percentage of Gross National Product, 1965 and Projected 1980 and 2000

Sector	1965 (Estimated)	1980	2000
	Percent		
Agriculture.............	4.0	2.6	1.6
Manufacturing..........	29.9	32.8	29.9
All other..............	66.1	64.6	68.5

Source: 1965 data from [3].

In drawing up the projections by industrial sectors, GPO projections to 1977 by the National Planning Association [3] were extrapolated to 1980. In continuing the projections to 2000, prospective changes in the relative importance of agriculture and manufacturing and the prospective growth of governmental and other services between 1980 and 2000 were taken into account.

Within each of the industrial sectors, the distribution of the national GPO among States and regions was also projected, taking into account the historical trends and the NPA projections. The projected total GPO for each region is the sum of the projected sector figures for that region.

Regional Personal Income

To project regional personal income, national totals were derived from the projections of GNP and from the relationship between personal income and GNP projected by the National Planning Association [4]. The available NPA projections (to 1975) of the relation between each State's per capita income and that of the Nation was then considered (table 19). Projections for 1980 and 2000 were based on the figures for 1975 and on the indicated trends, taking into account the long-term trend toward equalization of the differing regional levels of per capita income.

Table 15. National and Regional Gross Product Originating, 1960 and Projected 1980 and 2000

(in millions of 1958 dollars)

Region	1960 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
United States..	484,482	1,078,990	1,176,500	1,210,700	2,199,540	2,602,700	2,878,390
Northeast.....	137,851	273,510	298,220	306,890	518,200	613,180	678,130
North Central.	143,660	304,000	331,470	341,110	596,510	705,840	780,600
South.........	121,819	291,030	317,560	326,780	620,790	734,560	812,380
West: [a]	81,152	210,450	229,250	235,920	464,040	594,120	607,280
Montana......	1,640	3,390	3,700	3,810	6,970	8,240	9,120
Idaho........	1,469	3,100	3,390	3,500	6,260	7,410	8,190
Wyoming......	955	1,570	1,730	1,770	3,210	3,810	4,200
Colorado.....	4,782	12,550	13,680	14,080	28,210	33,390	36,930
New Mexico ..	2,217	5,380	5,870	6,030	12,120	14,330	15,840
Arizona	3,248	10,730	11,720	12,050	25,970	30,740	33,990
Utah	2,236	5,740	6,250	6,440	13,290	15,730	17,400
Nevada	947	3,660	3,980	4,100	9,280	10,970	12,140
Washington ..	7,656	17,540	18,570	19,110	34,330	40,620	44,320
Oregon	4,686	9,550	10,410	10,720	17,280	20,460	22,620
California ..	48,900	131,350	143,210	147,380	291,110	344,460	380,950

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[a] Includes Alaska and Hawaii.

Source: 1960 Data from [4].

Table 16. National and Regional Gross Product Originating in Agriculture, 1960 and Projected 1980 and 2000

(in million 1958 dollars)

Region	1960 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
United States[a]...	23,334	28,050	30,600	31,480	35,190	41,600	46,050
Northeast.......	1,966	1,940	2,110	2,170	2,150	2,540	2,810
North Central...	8,231	10,580	11,540	11,870	13,690	16,180	17,910
South..........	8,687	10,460	11,420	11,740	13,130	15,520	17,180
West:[a]	4,450	5,070	5,530	5,700	6,220	7,360	8,150
Montana.......	238	250	270	280	280	330	370
Idaho.........	235	310	340	350	420	500	550
Wyoming.......	94	80	90	90	70	80	90
Colorado......	288	310	340	350	350	420	460
New Mexico....	158	150	160	160	160	180	190
Arizona.......	265	250	280	280	280	330	370
Utah..........	90	140	150	160	210	250	280
Nevada........	28	30	30	30	40	40	50
Washington....	429	560	610	630	740	870	970
Oregon........	298	450	490	500	630	750	830
California....	2,181	2,410	2,630	2,700	2,890	3,410	3,780

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[a] Includes Alaska and Hawaii.

Source: 1960 data from [4].

Table 17. National and Regional Gross Product Originating in Manufacturing, 1960 and Projected 1980 and 2000

(in million 1958 dollars)

Region	1960 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
United States a/...	138,583	353,910	385,900	397,030	657,710	778,200	860,640
Northeast.......	45,927	96,260	105,350	108,410	160,470	189,880	210,000
North Central...	48,188	112,190	122,330	125,890	198,610	235,020	259,910
South a/.........	26,766	82,810	90,300	92,920	167,700	198,440	219,460
West: a/	17,702	62,290	67,920	69,810	130,930	154,860	171,270
Montana.......	169	350	390	400	660	780	860
Idaho.........	236	700	770	800	1,320	1,560	1,720
Wyoming.......	67	100	120	120	130	160	170
Colorado......	734	2,480	2,700	2,780	5,260	6,230	6,890
New Mexico....	137	350	390	400	660	780	860
Arizona.......	406	2,120	2,320	2,380	4,600	5,450	6,020
Utah..........	388	1,420	1,540	1,590	3,290	3,890	4,300
Nevada........	44	140	150	160	200	230	260
Washington....	1,930	6,020	6,560	6,750	12,500	14,790	16,350
Oregon........	1,205	2,830	3,080	3,180	4,600	5,450	6,020
California....	12,169	44,600	48,620	50,040	95,360	112,840	124,790

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a/ Includes Alaska and Hawaii.

Source: 1960 data from [4].

Table 18. National and Regional Gross Product Originating in All Sectors Other Than Manufacturing and Agriculture, 1960 and Projected 1980 and 2000

(in million 1958 dollars)

Region	1960 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
United States a/....	322,565	697,030	760,000	782,110	1,506,700	1,782,900	1,971,700
Northeast........	89,958	174,950	190,760	196,310	355,580	420,760	465,320
North Central....	87,241	181,230	197,600	203,350	384,210	454,640	502,780
South a/..........	86,366	197,760	215,840	222,120	439,960	520,600	575,740
West: a/	59,000	143,090	155,800	160,330	326,950	386,900	427,860
Montana........	1,233	2,790	3,040	3,130	6,030	7,130	7,890
Idaho..........	998	2,090	2,280	2,350	4,520	5,350	5,920
Wyoming........	794	1,390	1,520	1,560	3,010	3,570	3,940
Colorado.......	3,760	9,760	10,640	10,950	22,600	26,740	29,580
New Mexico.....	1,922	4,880	5,320	5,470	11,300	13,370	14,790
Arizona........	2,577	8,360	9,120	9,390	21,090	24,960	27,600
Utah...........	1,758	4,180	4,560	4,690	9,790	11,590	12,820
Nevada.........	875	3,490	3,800	3,910	9,040	10,700	11,830
Washington.....	5,297	10,960	11,400	11,730	21,090	24,960	27,000
Oregon.........	3,183	6,270	6,840	7,040	12,050	14,260	15,770
California.....	34,550	84,340	91,960	94,640	192,860	228,210	252,380

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a/ Includes Alaska and Hawaii.

Source: 1960 data from [4].

Table 19. National, Regional and State Personal Income, 1965 and Projected 1980 and 2000

(in million 1958 dollars)

Region	1965 (Estimated)[a]	1980			2000		
		Low	Medium	High	Low	Medium	High
United States[b]...	494,700	837,980	935,320	962,510	1,748,600	2,069,230	2,288,330
Northeast.......	134,540	204,140	227,860	234,480	391,340	463,110	512,140
North Central...	142,990	217,750	243,040	250,000	434,580	514,270	534,450
South..........	122,970	236,310	263,760	271,430	561,210	664,130	734,450
West:[b]	94,200	179,780	200,660	206,600	361,470	427,720	507,290
Montana.......	1,560	2,720	3,040	3,130	5,660	6,690	7,400
Idaho.........	1,560	2,490	2,780	2,860	5,410	6,400	7,080
Wyoming.......	730	1,410	1,570	1,620	2,780	3,290	3,640
Colorado......	4,870	9,770	10,900	11,220	19,440	23,000	25,440
New Mexico....	2,020	4,180	4,670	4,800	10,740	12,710	14,060
Arizona.......	3,400	8,440	9,420	9,700	20,400	24,140	26,700
Utah..........	2,110	4,270	4,760	4,900	10,300	12,180	13,470
Nevada........	1,290	3,190	3,560	3,670	5,560	6,580	7,280
Washington....	7,900	13,080	14,590	15,020	26,250	31,070	34,360
Oregon........	4,960	8,360	9,330	9,600	9,970	11,800	13,050
Calfornia.....	55,100	117,040	130,640	134,440	235,700	278,920	308,460

[a] Historical series in current dollars.
[b] Includes Alaska and Hawaii.

Source: 1965 data from [10, p.327].

CHAPTER II

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CHAPTER III

AGRICULTURAL COMMODITIES AND FORAGES

Projections of the consumption levels for major grain commodities, cotton lint and wool, forages, and selected meats are presented in this chapter. Three levels of domestic consumption and export requirements in 1980 and 2000 (high, low, and medium) are given for wheat used as food; corn and all other grains grown principally for feeding purposes; soybeans; beef, veal, lamb, and mutton; and cotton fiber and wool. Because the factors which influence export levels for many of these agricultural crops are independent of the determinants of domestic consumption, separate estimates have been made for domestic and foreign trade prospects. This chapter also contains projections of the levels of forage consumption in 1980 and 2000, expressed in terms of both pasture requirements and the direct consumption of roughage harvested mechanically and fed to domestic animals.

Multiple regression equations were developed to explain annual variations in domestic consumption of most commodities, or the combined disappearance of several grains classified by similar end-uses, during the period 1948-65. The step-wise multiple regression program selected for this work allowed the selection of the "best" equations from a wide variety of solutions. The more suitable equation provided guidelines for most projections of domestic consumption.

Major determinants of the quantity of agricultural products exported from the United States are not specifically covered by the economic indicators and demographic projections included in Chapter II, nor are the other determinants of domestic consumption which were developed specifically for these commodities appropriate for projecting export levels. The specific low, medium, and high projections of exports of food, feed, and fiber rely heavily on judgments of probable U.S. foreign trade and food aid policies, policy developments of importing countries, different prospects for import demands in primary commercial markets, and, finally, the quantities of exports under concessional terms which probably will be made available for and be acceptable to free world developing countries.

Grains and Soybeans

In making the projections of the domestic use of grains, it was recognized that any major cereal crop has several distinct, important alternate uses. The traditional classifications of most grains as either bread or feed grains has become misleading. Several examples of dramatic changes in the domestic demand structure for cereal crops during the past 20 years illustrate this point. Currently, the food and industrial uses of corn and other "feed" grains are more than 65 percent of the quantity of wheat used for food. Moreover, while the total demand for wheat flour and breakfast foods has leveled off, the consumption of other grains for certain types of food has grown at annual rates up to 8 percent in recent years. On the other hand, since 1964, significantly larger quantities of wheat have been fed to livestock and poultry. Several kinds of wheat should continue to be used as feed grains as long as this grain remains competitively priced with corn and other feed grains in many parts of this country. In fact, if current yield and price trends of several crops are assumed to continue, then it is reasonably certain that wheat will become more important to the feed-livestock economy than either barley or grain sorghum.

The factors which readily explain and presumably determine the amount of a given grain consumed by one end use may have little influence in explaining the quantity of the same commodity used for a different purpose. For example, the reasons why the rapidly growing corn refining industry has absorbed progressively larger amounts of that grain during most years since 1952 should not be expected to explain why less corn is used today by brewers and distillers than was needed 18 years ago.

In order to prepare realistic projections of the domestic consumption of wheat, corn, and other grains, except rice and rye consumed as flour, precise but simple explanations of the historic use of the several competing grains by principal end use were prepared. To take full advantage of the time series data available for both consumption and suitable explanatory factors, closely related end uses were aggregated.

Wheat Used as Food

The total quantity of wheat consumed as food in this country has remained remarkably constant for several decades; U.S. consumers and the military abroad currently use approximately 510 million bushels annually, compared with the consumption of 490 million bushels of wheat in flour and other wheat products 20 years ago. In terms of per capita consumption, wheat used as food declined from 198 pounds per year in 1948-50 to 159 pounds in 1963-65, representing a compound annual rate of decline of 1 percent. The rate of decline has diminished since 1960, however, and there is evidence that per capita use may have reached a minimum in 1968.

The rise in per capita disposable income explains 97 percent of the annual variation in wheat consumption per person during the 18-year period, 1948-65. On the average, an increase of $100 in personal income after taxes was associated with a decrease of about 7.2 pounds of wheat. During the last 20 years, consumers clearly demonstrated their preference for other foods. In another regression equation which did not include income as a factor, time (as a measure of change in taste) and wheat prices together also explained nearly all (99 percent) of the annual variation in consumption during the same period. Although price was the least important factor, some consumer resistance was apparent.

Projections of Wheat Consumed as Food

Total wheat made into flour and breakfast cereal for domestic use is projected to increase very slightly during the last quarter of this century. By 1980, the most likely estimate suggests an annual consumption of 541 million bushels, only 5 percent above 1965 levels (table 20). In 2000, under similar stipulations, use is expected to be only another 8 percent higher. The high projection would be significantly larger if any of several possible changes in the market structure for wheat products were stipulated. If wheat prices to the flour miller were reduced and kept at sharply lower levels (instead of the high figures we believe more likely), the milling industry could then offer bakeries and food manufacturers a wider range of flour products, or at least could price these products more competitively compared with flours from other cereal crops. The development of a major new flour product, another food use for wheat, or perhaps merely a radical shift in "product mixes" (resulting from the aggressive promotion of certain "minor" products) obviously would result in a modification of the estimates, all of which are based on gradual further declines in per capita consumption.

Table 20. Wheat and Other Grains, U.S. Consumption for Food and Selected Industrial Uses, 1965 and Projected[a] 1980 and 2000

(in million tons except where noted)

Grain and industrial use	1965 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Wheat for domestic food[b]	15.2	15.3	16.2	17.6	16.0	17.5	20.9
(million bushels)..........	(507.7)	(510)	(540.9)	(588.4)	(532)	(584.8)	(698.5)
Other grains:							
Corn refining industry......	5.7	7.0	7.3	7.3	8.8	9.3	9.6
Fermented malt liquors......	3.3	4.6	5.3	5.5	4.7	8.5	9.9
Alcohol and distilled spirits[c]	1.2	1.3	1.5	2.5	1.3	1.7	2.3
Dry milling (corn, oats, barley)....................	1.2	1.3	1.3	1.4	1.7	1.8	2.1
Total corn and other feed grains..................	11.4	14.2	15.4	16.7	16.5	21.3	23.9
Total all grains.............	26.6	29.5	31.6	34.3	32.5	38.8	44.8

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a/ No allowance for seed use.

b/ Includes use by military at home and abroad. Does not include wheat fed to livestock and poultry or wheat equivalent of flour and other wheat products exported.

c/ Includes rye and small quantity of wheat. In 1965, these grains constituted 0.103 tons, or 8.5 percent of all grains used by this industry.

d/ Projections include small quantity of grain products manufactured in the United States and then exported.

Source: 1965 data from [3. 8, 9. 20]

Industrial Uses of Grain

Corn and other grains are used to manufacture a wide variety of foods, alcoholic beverages, and industrial products. Collectively, these industries constitute a tremendous market for agricultural raw materials. Each industry has exhibited distinctly different growth patterns during the past 20 years.

The corn refining industry has become the single largest user of grains which are not fed to livestock or ground into wheat flour. This industry uses a wet milling process to manufacture starch, syrup, sugar, corn oil, and high-protein animal feeds which are produced as by-products. Grindings of corn increased from a yearly average of 119.2 million bushels in 1948-50 to 194.6 bushels in 1963-65. Since 1961, growth has been at an annual compound rate of 6.9 percent. A major new market was developed with margarine manufacturers when corn oil replaced part of the cottonseed oil previously used. Regression analyses indicate that practically all (99 percent) of the annual variations in corn consumption by the wet millers between 1948 and 1965 are explained by different combinations of three factors. Of prime importance was the FRB index for food manufacturing. Since 1962, an increase of 1 point in this index was associated with an increase of 1.4 million bushels of corn used by corn refiners.

The price of corn oil was also a significant indicator of corn use by industry. At average prices, an increase in corn oil price of 1 cent per pound was associated with a decrease in wet mill grindings the following year of approximately 1.8 million bushels.

Other food manufacturers using dry milling procedures to produce cornmeal, breakfast foods made of corn and oats, various other corn products, and barley malt for food manufacturers, collectively take much less grain today than does the corn refining industry. In fact, per capita consumption of these food products has declined from a 1948-50 average of 18 pounds to a 1963-65 equivalent of 12.7 pounds. The net decrease in per capita use is explained entirely by the sharp decline in the demand for cornmeal, which is a logical response to both the declining rural population and rising personal incomes. On balance, the average consumer increased his use of breakfast foods made of corn and oats, which are convenience foods.

Brewers and other manufacturers of fermented malt liquors have increased their use of barley and corn by about 15 percent during the past 20 years. In terms of per capita use (for each person between 21 and 75 years of age), beer and ale makers requirements increased at an average of only 0.5 percent a year between 1948 and 1965. However, since 1962 grain consumption has increased at an annual compound rate of 3.5 percent. By 1963-65, grain taken by this industry had increased to over 3.2 million tons, which placed brewers as the second most important users of grains.

Two factors explained as much as 88 percent of the annual variation in the annual use of these two grains between 1948 and 1965. The prices of alcoholic beverages and the annual per capita personal consumption expenditures for alcoholic beverages were the prime consumption indicators for the industry.

In terms of annual grain consumption, liquor distilling now ranks at the bottom, slightly below breakfast food manufacturers and makers of cornmeal. Purchases of corn and rye by distillers actually declined during the last 20 years, and whiskey production declined at an average annual rate of about 1.6 percent between 1948 and 1964. Taxable withdrawals of whiskey from warehouses increased about 60 percent, however.

Most of the grain bought by distillers after World War II apparently was used to make whiskey which was stored, rather than sold to consumers, during the early fifties. It would be extremely difficult to allocate the grains bought for whiskey production and other end uses by liquor distillers and industrial alcohol producers. It was assumed that taxable withdrawals of whiskey over long periods of time would be an accurate benchmark for the grain consumed by distillers.

Projections of the Consumption of Grain for Food and Industrial Uses

During 1963-65, slightly over 11 million tons of corn, barley, oats, and grain sorghum were used each year to manufacture various food products and alcoholic beverages. This quantity corresponded to about 9 percent of all grains fed to livestock annually during the same period. Grain products

manufactured from about 0.5 million tons of grain were exported annually.[1]

Assuming medium levels of population, industrial output, and the most probable levels for other important factors, the manufacture of consumer products and beverages in 1980 is projected to consume 15.4 million tons of grains (table 20). Under similar stipulations, makers of grain food products and alcoholic beverages will take 21.3 million tons in 2000 (table 20). Such projections of total prospective demand for grain products and alcohol do not indicate probable changes in use of corn and other feed grains by each grain-using industry.

The calculations indicate that the corn refining industry will continue to be the major grain consumer, taking nearly half of the grains[2] sold to make food products and alcoholic beverages. Medium projections indicate that these wet-process millers will grind approximately 7.3 million tons of corn in 1980, and around 9.3 million tons at the end of this century (table 20). These consumption projections imply average annual growth rates each year of 1.8 percent through 1980, and 1.3 percent during the 1980's and 1990's, or much slower rates of growth than this industry demonstrated during the early sixties (6.9 percent). It is expected that the output of food manufacturers will grow significantly less rapidly than total nondurable manufacturing during the next 30 years. Excepting the possibility of a major new market for corn oil or other corn products made by the wet milling process, corn requirements for this industry should grow only slightly faster than population through 1980, and increase at about the same rate as population through the end of this century.

Prospects for grain use by a competing industry, the dry milling industry, suggest that grain used to make cornmeal and breakfast foods most likely will increase to approximately 1.3 million tons of corn, oats, and barley by 1980, and then will continue to grow at the slightly higher annual compound rate of 1.6 percent through 2000, reaching levels of 1.8 million tons a year by the end of this century (table 20).

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[1] Since exports of these grain products were insignificant compared with domestic consumption of exports of the processed grains, no additional export projections were made.
[2] Except wheat, rye used as flour, and rice.

Because per capita purchases of cornmeal are expected to continue to decline, annual net growth in grain used to manufacture these food products should be very small during the next 15 years.

Barley and corn growers should find an expanding market in the brewing industry during the next 30 years. The medium estimate is that grain purchased by domestic beer and ale makers will increase from a 1963-65 base of 3.2 million to 5.26 million tons by 1980, and to 8.5 million tons by 2000. These increases in demand reflect a stipulation that personal consumption expenditures for alcoholic beverages per person will increase substantially, to record levels by 1980. Increases in population and prospects for moderate declines in alcoholic beverage prices are of minor importance.

Grains used to make whiskey and other distilled spirits will reach levels of 1.5 million tons by 1980, according to the medium projections. This quantity represents a 35-percent increase above consumption for similar purposes in 1963-65. It is in line with projected increases in taxable withdrawals of whiskey stocks. It is assumed that grain requirements of distillers will not be materially influenced by large changes in inventories, such as occurred during the early fifties. By 2000, the liquor distilling industry will take nearly 1.7 million tons, consistent with the most likely projection (table 20).

The eating habits of the average American will change substantially during the next 30 years, according to the medium estimates for per capita consumption of selected agricultural commodities. However, most changes in prospect are consistent with current consumer choices, or tastes and preferences developed during the past 20 years (table 21). In general, food products which increased in popularity during the 1950's and early 1960's will continue to be preferred during the next 30 years by most consumers. Similarly, kinds of food which consumers found less acceptable in the past usually will continue to be less acceptable by more Americans. Cumulative changes in the eating habits of the next several generations of Americans may indicate large shifts from present diets.

Table 21. Per Capita Consumption Increase (+) or Decrease (-) in Consumption of Selected Foods in the United States, 1963-65 Average and Projected (Medium) 1980 and 2000, with Comparisons

Food	1963-65 Average		1980		2000	
	Per capita consumption	Compared with 1948-50a/	Per capita consumption	Compared with 1963-65a/	Per capita consumption	Compared with 1980a/
	Pounds	Percent	Pounds	Percent	Pounds	Percent
Beef..............	97.8	+54.0	129.05	+31.9	178.2	+38.1
Veal..............	5.1	-42.1	2.45	-52.0	1.6	-41.6
Lamb and mutton...	4.27	- 3.0	3.88	- 9.0	4.29	+10.6
Wheat products....	159.0	-20.0	138.0	-13.3	114.3	- 7.6
Other grain productsb/.......	44.9	- 4.3	47.0	+ 4.7	46.7	- 0.6

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a/ Increase or decrease.
b/ Does not include alcoholic beverages, rye flour, milled rice, or corn oil. May include some duplication between corn products produced by both wet-process and dry-milling industries.

Source: 1963-65 data from [3, 6, 8, 9, 12, 15].

Feed Grains

Corn and most other cereal crops, including wheat and rye, substitute at relatively constant efficiencies in most animal and poultry rations. Therefore, the total feed consumed by livestock can be expressed in terms of feed units, which weigh actual quantities of a given grain according to its feeding value relative to corn. This simplifies the task in projecting domestic demand levels for feed grains other than corn. The entire annual consumption of all grains fed to livestock, including wheat and rye, can be calculated and expressed as a single estimate in terms of corn equivalents. To corroborate such an estimate, only the consumption of corn should be determined separately. Nearly three-fourths of the total grain usually fed in this country is corn.

Total grain fed to domestic animals and poultry increased from a 1948-50 average of 97.2 million tons, corn equivalent, to a 1963-65 average of 122.5 million tons. This rise in consumption represents an average increase of 1.6 percent each year.

Of prime importance in explaining the annual variation in the quantity of all grains fed during 1948-65 was a variable measuring the joint or combined effects of total personal consumption expenditures and a price ratio which measured the price levels of all foods relative to prices of livestock products only. At average values of this factor, an increase of approximately $10 billion by persons for goods and services was associated with the feeding of an additional 3.3 million tons of grain the following year.

The decline in grain feeding, which resulted from the greater substitution of high-protein feeds for part of the grain component in more efficient feeding formulas, is clearly indicated. For each 1-percent increase in the tonnage of high-protein feed supplements consumed compared with the total concentrates and all grains and commercially prepared feeds, annual grain consumption was lowered nearly 8 million tons. Since the portion of high-protein feeds in the total (concentrate) ration increased from 7 percent to over 11 percent during the 18-year period, this factor alone offers ample reason for the relatively modest growth of grain feeding.

During the 1948-65 period, corn fed to livestock increased from a 1948-50 average of approximately 71.4 million

tons to 88.7 million tons annual average in 1963-65, representing an average increase of 1.5 percent per year. Two factors alone account for approximately 93 percent of the annual variation in corn fed during this 18-year period. The dominant influence was the animal rate of feeding of high-protein feeds to livestock, which increased nearly 25 percent from 1956 through 1961, and again in the mid-sixties. This particular variable is one way to measure many important changes in livestock feeding practices which occurred in the past 20 years. Improvements in livestock breeding, feeding, and management turned animals and poultry into increasingly efficient converters of feeds into meat, milk, and eggs.

The second most influential factor was the relative amount of high-protein feeds in the total (concentrate) ration. A decrease of approximately 11.5 million tons of corn fed per year was associated with a 1-percent increase in the proportion of total feed concentrates classified as high-protein feeds. Prices of livestock relative to feed grains and hay, and prices of corn relative to all feed grains, were of comparatively minor importance.

Regression analysis indicates that the factors discussed above collectively explain 97 percent of the quantity of corn fed to livestock and poultry each year between 1948 and 1965.

Projections of the Domestic Consumption of Feed Grains

Total grains fed to livestock and poultry in 1980 is projected at 49 percent above 1963-65 levels (table 22). This estimate is consistent with the medium assumptions concerning total personal consumption expenditures, livestock feeding practices, and price relationships in 15 years. Grains used to produce meat, dairy and poultry products in 2000 are forecast at 278 million tons, corn equivalent. These increases in prospective demands for feed imply average growth rates of 2.5 percent during the next 15 years, and 2.2 percent each year during the following two decades, compared with actual increases in feed grain consumption of 1.6 percent per year from 1949-64. However, feed grain consumption is expected to grow slightly less rapidly in the future relative to use during 1956-64, when consumption of feed grains by livestock and poultry increased at an annual compound rate of 3 percent. Comparisons of our high and low projections for 1980 and 2000

Table 22. All Feed Grains, Corn Only, and Soybeans: Quantities Fed to Livestock and Poultry or Processed into Soybean Products in the United States, 1965 and Projected 1980 and 2000

(Million tons, except where noted)

Commodity and use	1965 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Six grains fed[a]	130.0	165.4	182.3	191.1	247.8	277.9	320.9
Corn[b] fed	95.4	130.2	135.0	138.8	194.4	209.8	219.3
Soybeans processed by U.S. oilseed mills	16.12	22.77	23.75	25.77	29.94	31.87	35.31
(million bushels)	537.5	759.1	791.8	859.0	997.9	1,062.4	1,177.0

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[a] Million tons of feed units of corn, barley, oats, rye, sorghum grain, and wheat.
[b] Includes allowance for grain in corn silage fed.

Source: 1965 data from [6, 8, 15, 18].

(table 22) suggest alternate prospective demands for feed grains, congruent with contrasting sets of assumptions.

Corn fed to livestock and poultry is predicted to increase to about 135 million tons by 1980, up from the 1963-65 average of 88.7 million. Corn consumption for these purposes may total 210 million tons per year by 2000 (table 22). These medium projections imply annual growth rates of over 2.5 percent and 2.3 percent, respectively, and suggest that approximately 75 percent of the total feed grains fed 30 years from now will be corn, compared with 72 percent in 1963-65. The medium and high estimates for corn use stipulate that average price relationships will encourage the feeding of corn. The low forecast assumes 1963 average price relationships will continue during the next 30 years.

Soybeans

During 1948-50, oil seed processors crushed an average of 210.3 million bushels of soybeans each year. During 1963-65, the industry consumed an average 483.8 million bushels each year. This increase represented a remarkable growth rate of 5.7 percent compounded annually. The persistent and sustained growth of the soybean processing industry is a clear measure of its ability to process and profitably merchandise soybean oil and soybean meal both here and abroad.

Several variables explain as much as 97 percent of the variation in annual soybean crush during the 1948-65 period. The FBR industrial production index for food manufactures was of primary importance. An increase of 10 points in this index was associated with the crushing of an additional 66.2 million bushels of soybeans. Secondly, at average values of livestock relative to feed grains, an increase in livestock prices of 1 percent was associated with an increase in soybean crush of over 2 million bushels during the following year. Finally, an increase of 1 percent in livestock prices was associated with an additional crush of 1.3 million bushels during the same feeding year. These relationships emphasize how responsive soybean processors have become in meeting the dynamic requirements of their own customers (the refiners of soybean oil and the animal feed manufacturing industry).

Projections of the Consumption of Soybeans

Soybeans processed in 1980 may total 792 million bushels, compared with a 484 million bushel average during 1963-65. In 2000, the annual tonnage of soybeans "crushed" by domestic oilseed mills should be 120 percent above 1963-65 requirements (table 22). The increased consumption indicated by these medium projections implies annual compound growth rates of 3.1 percent and 1.5 percent, respectively, or significantly lower rates of expansion than actually attained by this industry from 1949-64 (5.7 percent).

There are two possibilities which are not stipulated as occurring within the next 30 years, but which could cause the projections of domestic soybean crush to be exceeded. The U.S. soybean industry may acquire major new commercial or concessional (subsidized) markets abroad for soybean oil in countries which do not have oilseed processing plants. Less likely, but still possible, soybean products may in time develop major uses in the creation of high-protein foods marketable where animal proteins are too expensive or otherwise unacceptable. Food technologists have developed several high-protein foods and the widespread nutritional need for additional protein has been demonstrated, but commercial marketing of these products in developing countries has not been successful [1]. We assume that U.S. soybeans crushed in this country will continue to be processed for vegetable oil products and livestock feeds. This assumption may be valid only if food processors are not provided with major incentives to develop the market.

Prospective demands for all feed concentrates[3] consistent with the medium projections of feed grain and soybean consumption indicate that approximately 48 percent more feed concentrates will be consumed in 1980 than were used in 1963-65, and that equivalent disappearance some 30 years from now probably would be more than double recent use (table 23). Increased demand for feed grains other than corn should also double within the next 30 years, under our assumption of most probable relative prices of corn and all feed grains. Barring major yield increases in oats and barley relative to corn, we would stipulate that most of this additional grain would be

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3/ Grains and high- and low-protein manufactured feeds, including by-product feeds.

Table 23. U.S. Feed Concentrate Consumption, by Principal Kind of Feed, 1963-65 Average and Estimated 1980 and 2000

(Million tons)

Type of feed	1963-65 Average	1980[a]	2000[a]
All grains......................	122.5	182.3	277.9
Corn only....................	88.7	135.0	209.8
Other five grains.............	33.8	47.3	68.1
By-product feeds (low protein)[b].	15.0	20.0	20.0
All high protein feeds..........	18.4	28.4	43.1
Soybean meal.................	11.46	18.77	25.17
Other........................	6.99	9.5	18.14
Total concentrates fed..........	155.9	230.7	341.0

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a/ Based partly on medium projections of feed grains fed (table 21) and soybeans processed by domestic oilseed mills (table 22). Estimated quantities of other high protein feeds are adequate to provide balance of that class of feeds in the entire ration.

b/ Grain protein feeds and other by-product feeds are not classified as high-protein feeds. Slight increases in production of grain protein feeds by 2000 are estimated to be offset by reductions in output of most other by-products.

Source: 1963-65 data from [8].

either grain sorghum or wheat. Provided wheat were priced competitively for livestock feeding purposes, as much as 15 million tons (450 million bushels) might be fed.

Regarding total requirements for high-protein feeds, it should be noted that our projections of domestic soybean consumption suggest that soybean meal supplies will represent a somewhat smaller part of all high-protein feeds used in 2000, compared with 1964 (58 percent and 62 percent, respectively). These estimates are consistent with several plausible developments. More of this leading conventional protein feed in cattle rations probably will be replaced by the synthetic protein source, urea. Demand for soybean supplement would also be lessened if plant breeders are successful in increasing the protein content of feed grains. Ample supplies of high-protein supplements which are produced as by-products of the meatpacking and other industries may reduce the relative importance of soybeans as a protein source in this country, since production in some of these industries may increase at slightly higher rates than that projected for soybean processing capacity.

Exports of Grains and Soybeans

Exports of U.S. grains and soybeans have increased much more rapidly during the last 20 years than has domestic consumption of these commodities. Moreover, since 1954, when the original Food for Peace Act, or Agricultural Trade Development and Assistance Act of 1954 (P.L. 480), signaled a major shift in agricultural and foreign policies of the United United States, exports of wheat and feed grains have grown even faster, increasing about 7 percent and 12.5 percent, respectively, each year. Soybean shipments abroad rose nearly 13 percent each year, on the average, since 1955. Practically all the increase in feed grain sales and soybeans shipped has been on commercial contracts.

While many factors obviously influence the scope of world trade in these primary commodities, preliminary findings based on both time series and cross-sectional (intercountry) analysis confirm these conclusions: increases in total and commercial imports of U.S. agricultural commodities are determined largely by growth of income and population; commercial imports increase faster than concessional transactions after the importing nation's economy starts growing significantly faster than its population.

Projections of exports of U.S. grains and soybeans in table 24 are consistent with the explicit assumptions concerning export determinents. Under all assumptions, exports are projected to exceed recent levels by large quantities. Wheat and soybean exports in 2000 should be larger than domestic use. Feed grain exports in 1980 and 2000 are estimated to exceed one-third of domestic feed grain requirements, compared with about 15 percent in 1963-65 (table 24).

Forages and Meat

Livestock grazing pastures and rangeland, and scavenging fields from which crops have already been harvested, contribute an immense quantity of feed. In fact, this grazing probably provides one-third of the entire feed nutrients consumed by all livestock. Obviously, for certain classes of livestock, adequate pasture is essential. Beef cattle usually consume more than one-half of such roughage,[4/] and thereby gather each year over 60 percent of all the feed that is converted to beef. Dairy cattle obtain one-third of their feed nutrients and eat about one-fourth of the national pasture crop. Sheep consume about 10 percent of the total feed derived annually from grazing, and convert this roughage into over 80 percent of the total feed required to produce the annual supply of lamb, mutton, and wool.[5/]

Forages which are harvested mechanically, mainly hay and silage, are consumed almost entirely by dairy cattle

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4/ Forage and roughage are used interchangeably in this section of the report, defined as all animal feeds other than feed concentrates. (Feed concentrates include all grains, by-product feeds, seeds, and noncommercial milk products.) Feed units derived from "pasture" include significant quantities of nutrients obtained by animals grazing meadows, harvested fields of field crops, etc. Harvested roughage includes hay silage and beet pulp, stover, and straw. Since forage consumption is measured in terms of feed units rather than actual weights, qualitative as well as quantitative aspects of roughage use is implied by this analysis.

5/ These estimates of percentage of feed nutrients derived are 1955-59 averages, as are corresponding figures given on the balance of this page and the page following [6, table 3]. More recent data suggest that these figures overestimate the importance of roughage for beef cattle.

Table 24. Exports of U.S. Grains and Soybeans, and Total Use of U.S. Soybeans, 1965 and Projected 1980 and 2000

(Million short tons, except where noted)

Commodity and use	1965 (Actual)	1980[a]			2000[a]		
		Low	Medium	High	Low	Medium	High
Wheat and wheat products exported..............	26.1	30.9	34.2	37.5	46.3	51.4	57.3
(million bushels).....	(867.2)	(1,028.7)	(1,140.0)	(1,250.0)	(1,543.2)	(1,712.3)	(1,910.0)
Feed grains exported....	29.1	44.0	52.9	53.4	83.8	93.5	99.2
Total grains exported (five grains)..........	55.1	74.9	87.1	90.9	130.1	144.9	156.5
Soybeans exported.......	7.5	14.4	19.2	21.6	20.1	32.25	42.0
(million bushels).....	(250)	(480)	(640)	(720)	(670)	(1,075)	(1,400)
Total use of U.S. soybeans[b].............	23.6	37.2	42.9	47.4	50.0	64.1	77.3

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a/ Wheat includes other grains fit for human consumption, except rye and rice which are not included in these estimates. Feed grain export projections include allowance for grain content of mixed livestock and poultry feeds sold abroad.
b/ Includes projections of domestic processing of soybeans, table 22.

Source: 1965 data from [6, 8, 9, 15, 18, 20].

(55 percent) and beef cattle (39 percent). The combined significance of the feeding value of all forages in the feed-livestock economy should be reemphasized: cattle and sheep consume practically all of the feed nutrients (95 percent) obtained from these roughages. About 92 percent and 84 percent of the total feed fed to sheep and all beef cattle, respectively, can be classified as either pasture or harvested roughage; 62 percent of the total feed used to produce our annual output of milk and other dairy products comes from forages. The total number of roughage-consuming animal units[6] increased from 1948-50 to 1963-65 at a small compound annual rate of 1.2 percent. Most of this increase occurred before 1954. Statistical analysis identified several factors which presumably explained up to 95 percent of the annual variation in these animal unit numbers during the 1948-65 period. Farmers and ranchers increased their herds in response to the large increases which occurred in total personal consumption expenditures, but animal unit numbers would probably have increased much more if livestock selling prices[7] had not declined substantially, especially since 1960.

Twenty years ago, livestock products, although high compared with food prices in general, were low priced relative to feed grains. From 1948 through 1959, livestock and milk producers responded to increasingly favorable livestock product to feed price ratios by increasing their breeding herds. However, during most of the last 10 years, as livestock prices continued to rise compared with feed costs, and since ample supplies of feeds of all kinds were available, ranchers and livestock feeders used more of their resources to produce and fatten grain-consuming animals, especially hogs and beef cattle. Livestock inventories, as measured by roughage-consuming animal units, would have been larger (since 1960) except for the marked decrease in number of dairy cattle and the comparatively large increase in beef cattle which were grain-fattened.

6/ Livestock numbers multiplied by weight to represent average relative annual consumption of pasture and other forages, by each kind of livestock. The benchmark for this series is the average annual forage consumption by one milk cow. In aggregating this series, cows, and cattle and sheep that are not grain fed receive the heaviest weight, while hogs, poultry, and grain-fattened beef cattle have no or negligible importance [15, 1965 Supplement].
7/ Deflated by index of retail food prices [2].

National average estimates of the amount of feed[8] each animal obtained from grazing and from harvested roughage fed increased about 0.8 percent and 1.1 percent per year, respectively, from 1948-50 through 1963-65. However, annual variations in the estimated consumption of these two classes of forage are best explained by different factors.

Three variables explain about 98 percent of annual variation of feed obtained from grazing during this 18-year period. Regression equations indicate that the amount of feed derived per animal from pasture varied closely with a grazing demand factor, which is expressed as a joint influence of both personal incomes and livestock prices. An index of pasture and range condition and hay prices compared with all feed prices was of secondary importance. Since the USDA index of pasture and range conditions declined somewhat during these years (on balance), the supply of available good pasture limited somewhat the increase in feed nutrients derived from grazing, particularly since 1960.

Nearly all (90 percent) of the annual variation in harvested roughage fed per animal unit from 1948-65 was explained by two other factors. Feeding rates of hay and silage tended to increase with increases in the contemporary levels of high-protein feeds fed per animal and with recent increases in the price of livestock compared with feed grain and hay prices.[9]

In summary, it can be concluded that the total forage requirements of the livestock population have increased moderately since 1948. Annual livestock inventories, aggregated and weighted according to estimated representative roughage consumption, probably have not increased significantly since the mid-fifties, but feed intake per animal has continued to increase in most years, and total feed derived from forage probably increased about 37 percent between 1948-50 and 1963-65. Finally, the statistical anlaysis confirmed that variations in livestock numbers and forage consumed per animal can be explained by appropriate factors.

Projections of Forages Use

Total feed nutrients (in terms of feed units on the feeding value of one ton of corn) derived by livestock from grazing is projected to increase 48 percent above 1963-65 consumption by 1980, and another 62 percent during the 1980's and 1990's. Equivalent estimates for feeding of mechanically harvested forages fed to livestock in view for 1980 and 2000 project that this class of feed will become slightly more important. It will most likely provide 52 percent and 150 percent more feeding value, respectively, compared with 1963-65 use. Consistent with these forecasts, total feed derived from all roughage is projected to increase nearly 50 percent by 1980 and then to expand another 63 percent before the end of this century (table 25).

Roughage-consuming animal unit numbers are projected to increase at slightly higher rates than the average feed derived per animal from either grazing or forages fed (table 25). The medium projections imply that livestock inventories (weighted by forage consumption) will increase, on the average, approximately 19 percent each decade. This growth rate is slightly higher than the average annual increase in this series which occurred between 1948-50 and 1963-65 (1.2 percent), but is considerably below the corresponding expansion rate attained between 1948 and 1953 (3.1 percent).

Projections of the Consumption of Beef, Veal, Lamb, and Mutton

During 1948-50, per capita consumption averaged 63.5 pounds of beef each year. In 1963-65, an average of 97.8 pounds per capita was consumed. This increase represents a compound annual rate of growth of 2.9 percent. The increase in personal income after taxes explains much of the increased demand for this particular meat. At recent high levels of

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[8] Expressed in feed units, or corn equivalents [6, table 23].

[9] The first of these two factors was of particular importance. High-protein feeds and some harvested forages often act as nutritional complements. Therefore, if more of one type of feed is fed, the efficient milk or meat producer will increase the feeding level of the other feed, at least when the protein content in the animal ration is relatively low. On the other hand, certain forages and high-protein supplements may act as nutritional substitutes (substituting at diminishing rates of feed conversion) at higher levels of protein in the ration.

Table 25. Feed Obtained by Animals in U.S. from Forages, per Animal-Unit and Total, by Grazing and from Mechanically-Harvested Forages, 1965 and Projected 1980 and 2000

(feed nutrients in million tons of feed units, corn equivalent)

Type of forage and unit of consumption	1965 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Pasture and other grazing:							
Per roughage-consuming animal unit..................	1.28	1.35	1.43	1.45	1.59	1.64	1.66
Total feed derived[a/]	132.48	166.66	194.01	208.04	265.41	314.53	339.04
Harvested forage fed:							
Per roughage-consuming animal unit..................	0.69	0.78	0.80	0.80	0.92	0.93	0.94
Total feed derived[a/]	71.41	96.51	108.22	115.16	149.88	177.89	192.53
All forages:							
Per roughage-consuming animal unit..................	1.97	2.14	2.24	2.25	2.49	2.57	2.60
Total feed derived[a/]	203.89	263.17	302.23	323.20	415.30	492.42	531.57

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a/ Projections of roughage-consuming animal units, in millions, are: for 1980, 122.96, 135.14, 143.1, respectively; and for 2000, 166.5, 191.2, and 204.7, respectively. In 1965, roughage-consuming animal units totaled 103.5 million.

Source: 1965 data from [6, 12, 15].

income, an increase of $100 in earnings after taxes resulted in an increase of at least 5.5 pounds of beef consumed. This preference for beef should continue to rise, although at a slower rate, as incomes continue to grow. During 1948-65, two factors, per capita disposable income and retail beef prices, explained up to 99 percent of the variation in annual per capita beef consumption.

The consumption of veal declined from a 1948-50 average of 8.8 pounds per person to a 1963-65 equivalent of 5.1 pounds per year. This decline represents an average annual compound rate of 3.6 percent, but most of the actual decline has occurred since the mid-fifties. Three factors explain 99 percent of changes in annual per capita consumption of veal during 1948-65: retail veal prices; time, which represents changing preferences for and the comparative availabilities of veal and other meats; and the price of veal compared with the price of beef. Since 1958, veal has become increasingly expensive compared with beef, and each time the price ratio increased by 10 percent, the per capita consumption of veal declined one-third of a pound. The declining trend in veal consumption reflects consumer preferences for other meats (notably beef and chicken). It also reflects a shrinking supply of veal which, in turn, is the direct result of the drop in size of the Nation's dairy herd, particularly since the mid-fifties.

The average American consumer is also eating slightly less lamb and mutton than the average consumer 20 years ago. Per capita consumption declined from an annual average of 4.4 pounds in 1948-50 to 4.27 pounds in 1963-65, or a compound annual rate of decline of 0.2 percent. However, the rate of decline has diminished since the mid-fifties. The average consumer increased lamb consumption by a total of approximately 1 pound per year between 1958 and 1962, presumably in response to progressively lower lamb prices and declines in the price of lamb compared with the price of beef. The three variables which explain approximately 86 percent of the annual variation in lamb consumption per person during 1948-65, listed in order of relative importance, are: time, as a measure of changing consumer preference; retail lamb prices; and the price of lamb compared with the price of beef at retail.

Projections of the Domestic Consumption of Beef, Veal and Mutton

Based on the assumptions concerning personal income, relative and absolute prices, and apparent trends in consumer preferences, total consumption of beef in this country is expected to continue to set new records during the next 30 years, but consumer purchases of veal are projected to decline sharply. Lamb and mutton demand probably will increase somewhat faster than population growth. In other words, the changes in consumer choice observed during the past 20 years are expected to persist and will dominate trends in demands for beef and veal. Prospects for lamb consumption are less certain. Under several alternatives, consumption should not continue to decline. Lamb may even gain slightly higher acceptance in many American households.

Total beef consumption in prospect implies annual increases each year of 3.2 percent to 1980, and 3 percent from 1980 through 2000, according to our medium assumptions (table 26). Our projection, consistent with higher incomes and lower beef prices, is that consumption will increase at 4.2 percent through 1980 and then grow at a slower rate (3.2 percent) during the 1980's and 1990's. By 2000, Americans are expected to consume nearly 190 percent more beef than the generation of 1965.

This increase in demand for beef will be coincident with a sharp drop in the quantity of veal eaten. Veal consumption is estimated to decline between 4.2 and 2.3 percent each year through 1980, consistent with our low and high projections (table 26).[10] By 2000, our medium projection indicates that veal consumption will be approximately half the 1965 level.

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[10] The unique position of veal as a by-product of the dairy industry complicates forecasts of consumption beyond 1980. However, even if it is stipulated that inventories of dairy cattle will decline at only a slightly slower rate during the last quarter of the century, high and medium consumption estimates are fully adequate to absorb veal production, assuming that no net export possibilities are developed. Conversely, the low forecast of veal use in 2000 may be too low relative to prospective supplies. Many veal calves by then might be marketed at lighter weights at premium prices, sold at heavier weights and classed as lower grade beef, or processed into cheaper meat products. However, a presumption of more rapid rate of decline in dairy cow requirements would suggest that, by 2000, little veal would be available, at least from domestic cows. In that case, it must be questioned whether consumption of imported veal would equal the estimates.

Table 26. U.S. Consumption of Selected Meats, 1965 and Projected 1980 and 2000

(Millions of pounds, carcass weight)

Type of Meat	1965 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Beef...............	19,032.0	25,513.8	30,352.6	35,528.9	40,849.5	54,707.4	66,741.2
Veal...............	992.5	523.7	576.2	703.7	282.5	491.2	627.6
Lamb and mutton....	830.9	701.3	912.6	1,264.1	1,121.5	1,317.0	1,851.6
Total selected meats.............	20,855.4	26,738.8	31,841.4	37,496.7	42,253.5	56,515.6	69,220.4

Source: 1965 data from [6, 12, 15].

Total lamb and mutton consumed is forecast to increase slightly, except under the lowest projection for 1980 (table 26). Annual increases of 2.8 and then 2.0 percent are implied by the highest assumptions. An overall growth of about 1.3 percent a year is considered most probable. By 2000, lamb and mutton consumption is projected at 35 percent, or 123 percent above 1965 levels.

Under stipulations of fairly low prices and favorable prices of lamb compared with beef, total lamb consumption will probably increase more rapidly than population increases, particularly during the next 15 years. The regression analysis explaining lamb consumed between 1948-65 indicates that a reversal in the decline in per capita lamb consumption is likely, if the time factor is extrapolated beyond 1966.[11]

Exports of Forages and Livestock Products

Only about 15 percent of the enormous U.S. hay crop is sold, the rest being fed on the farms where it is grown. The value of hay sales compared with production probably has increased slightly during the last 20 years (18 percent or 13 percent) [8]. Most of the hay which does enter commerce is sold in the same region as it is grown [11] and little is exported. Barring adoption of major innovations in production (packaging) technology, the restraints imposed by high shipping costs in the past should continue in the foreseeable future to limit exports of hay and harvested forages to negligible importance, relative to total U.S. domestic consumption of these feeds. If technology does provide economical methods for compressing hay into densities comparable with that of feed grains (field pelletizing or other packaging under extremely high pressure), then hay could become as much of a commercial commodity as corn. Under such circumstances a strong domestic market could develop for hay pellets, and it is assumed that little of the limited supply of this feed would be exported.

[11] This inference is consistent with the findings of cross-sectional data on the relationship of lamb consumption to family income in 1955 and 1965. The price elasticity of the demand for lamb was positive, and lamb consumption rose rapidly with increases in family income above medium levels, particularly in certain regions [17]. Projections of income distribution confirm that more household will enjoy higher incomes in the next several decades.

The total value of U.S. exports of all animals and animal products has been impressive: Since 1962, this commodity group has usually ranked fourth among the leading eight classifications of leading U.S. agricultural exports by value [10]. However, the great bulk of exports within this broad commodity group is classified as by-products of the meat-packing industry (chiefly variety meats, lard, tallow, and grease), of which the United States is normally the world's leading exporter. Dairy products and skims and poultry meat constitute the other principal categories of these exports [19], by value.

U.S. exports of beef and veal since 1958 have consistently equalled only 0.2 percent of domestic production. Lamb and mutton exports during 1958-66 ranged from 0.2 to 0.4 percent of U.S. production [12]. Furthermore, the U.S. trade in these meats is strongly imbalanced. The United States imports between 21 and 28 percent of the world's imports of beef and veal, while exporting less than 2 percent. Imports of lamb and mutton (mostly the latter) into the United States usually represent between 5 and 10 percent of the world's trade, and imports have recently constituted as much as 20 percent of U.S. production [14].

Exports of live animals, mostly cattle for breeding, similarly constituted negligible percentages of U.S. livestock inventories or production [12].

Meat prices for higher grade red meats are usually higher in the United States than in most large meat importing nations. Barring major relative changes in per capita incomes, it is considered extremely unlikely that foreign consumers will be able to outbid Americans for a significant part of U.S. production of higher quality beef and lamb in the foreseeable future. Furthermore, trade restrictions imposed by most developed nations should continue to stress policies of self-sufficiency in meat production.

Cotton (lint) and Wool

Total domestic consumption of cotton fiber for all purposes remained remarkably constant from 1952 through 1963. Recently, cotton apparently regained the slightly higher market demand which prevailed during the Korean War. In direct contrast to the trends in use of this major fiber, the FRB industrial production index for apparel products rose at a compound annual rate of 3.6 percent from 1948-50 to 1963-65, and the corresponding index for all textile mill products increased 2.2 percent annually. While cotton generally remained competitive with rayon and acetate during the last 20 years, it lost major markets to the noncellulosic man-made fibers.12/

Per capita purchases of all man-made fibers grew at a remarkable compound annual rate of 5.6 percent from 1948-50 through 1963-65. Most of this growth reflected increased demand for the noncellulosics, which are wholly synthesized, petroleum-based materials (e.g., nylon and dacron). Consumption of cotton per person remained quite constant from 1960 through 1964. The appropriate FRB indexes rose 18 points, and the use of these newer fibers increased over 10 pounds per person during the same 4-year period. More recently, cotton may have regained some of the ground it lost to rayon in the early sixties.

More than 90 percent of the annual variation in per capita domestic cotton consumption during 1948-50 was explained by changes in the FRB indexes for textile mill products and apparel products, and by changes in the ratio of cotton used compared with rayon and acetate consumption. As previously noted, consumption of man-made fibers during this period was highly correlated with both FRB indexes. This close relationship explains why declines in per capita cotton consumption were associated with rapid gains in output of these industries. Since 1961, in particular, growth in the American textile industry has been explained almost completely by the rapid gain in production of nylon, polyester, and acrylic fibers. Consumers have registered strong preferences for these newer noncellulosics, which have never been competitive in price with either cotton or rayon.

Makers of apparel products have always constituted cotton's main domestic customer. Since 1958, cotton has retained a larger share of the apparel market than the smaller fiber

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12/ Cotton's performance in the household and industrial markets was particularly noncompetitive. The tire cord market, which in 1950 took the equivalent of about 6 percent of recent total cotton consumption, was lost completely between 1951 and 1956. Since the mid-fifties, cotton lost much of its market in U.S. carpet mills to man-made fibers.

markets among makers of household products and industrial goods. The comparative advantage that cotton has enjoyed in the apparel market may appear to be slight, but it probably will be of critical importance to the future of this commodity. Therefore, it should be noted that cotton used for apparel purposes increased from less than 1.41 billion pounds in 1949-51 to nearly 1.89 billion pounds annual average in 1962-64. This increase in cotton disappearance, at a compound annual rate of approximately 2.3 percent, should be contrasted to corresponding changes in total apparent cotton consumption, which grew at a rate of 0.6 percent per year. Concurrently, industrial use of cotton fiber declined approximately 0.4 billion pounds.

Statistical analysis indicates that annual cotton consumption by apparel manufacturers increases 1 percent while the FRB index of apparel products increases 14 points, assuming constant prices between cotton and man-made fibers. However, for each 10-percent increase in the price of cotton goods relative to the prices of man-made fibers, cotton used for apparel purposes will decrease by more than 1 million pounds.

During 1948-64, these two factors explained approximately 98 percent of all variation in annual use of cotton in apparel products. Cotton prices increased about 8 percent relative to competing textiles between 1948 and 1965. If cotton prices had remained generally competitive with other fibers during this 18-year period, cotton probably would have held its initial share of the expanding apparel market. Instead, its market share declined from 66 to 60 percent.

In recent years, the United States has relied primarily on wool imports. In 1965, approximately 75 percent of the total wool consumed in the United States was imported.

Wool prices in the United States generally reflect world supply and demand conditions and domestic prices have tended to fluctuate directly with foreign prices. On a duty-paid basis, however, prices of imported wool at Boston are normally 10 to 20 percent higher than similar grades of domestic wool [22, p. 39].

Prices for wool were generally competitive with prices for noncellulosic fibers from the mid-fifties through the early sixties. Since that time, however, sharp price reductions of the noncellulosic fibers have tended to increase the relative price of wool. This reduction in noncellulosic fiber price accentuates the competitive advantage of synthetic fibers, which yield a greater amount of fabric per pound of fiber than does wool [22, p. 41].

In projecting wool consumption, it has been assumed that wool prices will fluctuate around the price levels of recent years. Also, it is assumed that the trend of decreasing noncellulosic fiber prices will continue. The only major factors which will contribute to the maintenance of current levels of wool consumption are the special characteristics of wool which make it a preferred fiber for climatic and other reasons.

Projections of the Domestic Consumption of Cotton and Wool

The projections for high, medium, and low consumption levels of all cotton fiber and fiber for apparel uses are consistent with the appropriate assumptions regarding total nondurable manufactures in 1980 and 2000, as presented in Chapter II of this report. Also, the projections are based on the assumption that no major breakthrough in cotton fiber technology is likely that would preclude man-made fibers, and particularly the noncellulosics, from acquiring many important new uses, as total fiber consumption expands rapidly in this country during the next 30 years. However, it is stipulated that cotton remains the fiber preferred by most apparel manufacturers, assuming that it is priced competitively with rayon, with the further supposition that cotton technologists can and will further limit loss of traditional cotton (apparel) markets to synthetics.[13]

Domestic cotton consumption for all uses is forecast to increase to slightly over 4.9 billion pounds (9.86 million bales) by 1980, consistent with our medium estimate of industrial production and other factors (table 27). Such a disappearance would indicate demand approximately 13 percent higher than average 1963-65 use. Total cotton use should expand at a rate slightly lower than projected population growth. In fact, the highest calculation indicates that per capita consumption will decline slightly to 21.2 pounds, compared with a 1963-65 average of about 22.8 pounds (table 27).

The medium and low estimates of cotton used for apparel purposes are consistent with the assumption that cotton products during the next 30 years will be priced less competitively than in the 1960's, compared with man-made fiber textile products. Experience during the last few years has demonstrated that man-made fibers will continue to become exceedingly more competitive, from the point of view of price as well as quality, regardless of lower cotton prices. Since April 1964, when domestic cotton prices were reduced sharply, the cotton man-made textile fibers price ratio has widened, and cotton goods currently are priced at historically high premiums over their principal competitors. Substantial reductions in prices of synthetic fibers more than offset earlier cotton price cuts.

Cotton lint used by apparel manufacturers is projected to increase nearly 3 percent each year through 1980, when consumption should exceed 3 billion pounds, or about 63 percent of cotton fibers used for all purposes (table 27). This medium projection is consistent with the assumptions concerning most likely output of apparel manufacturers and relative prices between cotton goods and man-made fiber textile products.

By 2000, total domestic consumption of cotton fiber for all purposes should be about 11 percent higher than projected 1980 requirements. According to the high projection, nearly 6.3 billion pounds of cotton will be used annually. The low estimate is slightly over 5 billion pounds (table 27).

Between 1980 and 2000, cotton fiber taken by clothing makers is forecast to increase between 1.1 and 1.8 percent each year, according to growth rates implied by low and high projections (table 27). The medium projection indicates cotton lint for this principal end use should be 31 percent higher at the end of this century than is projected for 1980. All projections recognize that cotton goods should become

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[13] This assumption is an implicit one, consistent with our supposition that cotton fiber technology may best be applied to apparel markets, rather than to regaining lost industrial outlets. Synthetic fibers blended with cotton to produce "permanent-press" fabrics represent the first major invasion of apparel products by noncellulosic fibers. This invasion into cotton territory may prove temporary, since research already underway could reverse this process.

Table 27. U.S. Domestic Consumption of Cotton Fiber and Exports of Raw Cotton, 1965 and Projected 1980 and 2000

(Billion pounds except as noted)

End use	1965 (Actual)	1980 Low	1980 Medium	1980 High	2000 Low	2000 Medium	2000 High
Domestic consumption:[a]							
Apparel manufacturing....	2,192.1[b]	2,938.2	3,096.5	3,160.0	3,642.1	4,056.1	4,281.0
Other uses.............	2,472.2	1,809.3	1,834.0	2,086.6	1,389.8	1,439.2	1,988.3
Total cotton lint used for all purposes.........	4,664.3	4,747.5	4,930.5	5,246.6	5,031.9	5,495.3	6,269.3
Million running bales..	9.33	9.49	9.86	10.49	10.06	10.99	12.54
Exports..................	1,471.0	1,350.0	2,690.0	3,100.0	2,400.0	2,860.0	3,450.0
Million running bales...	2.9	2.7	5.4	6.2	4.8	5.7	6.9

[a] Domestic consumption is U.S. mill consumption adjusted for raw fiber equivalent of net U.S. foreign trade in textile products. Projections assume that the U.S. will continue to be a net importer of cotton textiles.

[b] Estimated as 47 percent of total domestic consumption.

Source: 1965 data from [16, 21].

increasingly more expensive, compared with man-made textile fibers, and that demand for cotton by clothing manufacturers should expand considerably less rapidly than calculated growth in output of apparel products.

Projections of total wool consumption are based on recent trends in per capita consumption. The per capita consumption of wool by mills in the manufacture of apparel and carpets was projected graphically (table 28). The projected per capita consumption figures were than combined with the population projections (see Chapter II) to determine the projections of total consumption in 1980 and 2000.

Table 28. Per Capita Consumption of Wool, U.S. Domestic Mills, 1953-65 and Projected 1980 and 2000

Year	Pounds per capita wool for-- Apparel	Carpets	Total
1953...............	2.24	0.85	3.09
1954...............	1.66	0.71	2.37
1955...............	1.70	0.80	2.50
1956...............	1.76	0.86	2.62
1957...............	1.41	0.75	2.16
1958...............	1.22	0.68	1.90
1959...............	1.50	0.96	2.46
1960...............	1.36	0.91	2.27
1961...............	1.43	0.81	2.24
1962...............	1.50	0.80	2.30
1963...............	1.33	0.85	2.18
1964...............	1.22	0.63	1.85
1965...............	1.41	0.58	1.99
1980...............	1.25	0.65	1.90
2000...............	1.20	0.60	1.80

Source: Historical data from [23, p. 325].

Even though per capita consumption of wool is projected to continue to decline between 1965 and 2000, the total consumption of wool is expected to increase as the result of population increases. The medium projections for 1980 and 2000 indicate consumption levels of 446.9 and 554.1 million pounds, respectively, compared with the actual consumption of 386.9 million pounds in 1965 (table 29).

Table 29. U.S. Consumption of Wool, Domestic Mills, 1965 and Projected 1980 and 2000a/

(Millions of pounds)

End use	1965	1980			2000		
	Actual	Low	Medium	High	Low	Medium	High
Domestic mill consumptions.							
Apparel manufacture...	274.5	284.6	294.0	308.6	339.1	369.4	418.4
Carpet wool.	112.4	148.0	152.9	160.5	169.6	184.7	209.2
Total.....	386.9	432.6	446.9	469.1	508.7	554.1	627.6

a/ Includes Alaska and Hawaii.

Source: 1965 data from [23, pp. 374-5].

Exports of Cotton Fiber and Wool

Cotton exports have not increased during the past 20 years and presumably would have declined during the mid-fifties if large exports under P.L. 480 had not reversed the sizable decline following the Korean War period. Regardless, cotton exports in 1965 were still significant to the economy and the industry. Cotton lint foreign sales ranked seventh in value among the eight principal agricultural commodity groups, and constituted about 20 percent of the value of total U.S. farm sales of cotton [4, pp. 40-1].

Statistical analysis indicated that explanations of the decline in U.S. cotton commercial exports were complex. Only 54 percent of the annual variation was attributed to prices of U.S. cotton compared with world cotton prices [5].

Projections of U.S. cotton exports in 1980 and 2000 (table 27) indicate that foreign shipments should increase moderately, according to most likely assumptions and stipulations for high foreign demand. However, a marked decline in cotton exports is possible by 1980, consistent with domestic agricultural policies. Under the latter assumptions, the U.S. exports of cotton would be residual sales. That is, the United States would not compete actively with other cotton exporters, and domestic consumption would take all except approximately 2.8 million bales of the U.S. crop. Domestic agricultural policy is stipulated to discourage additional U.S. production beyond that needed to serve the moderately larger requirements of U.S. mills.

The current higher imports of wool indicate that future exports, to the degree they occur, will be negligible. It is not anticipated that any large portion of U.S. wool consumption will be met from domestic production.

CHAPTER III

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CHAPTER IV

CHEMICALS AND FERTILIZERS

Projections of three levels of domestic use and export shipments in 1980 and 2000 were made for phosphate rock, potash, and sulfur. Projections were also made of the industrial and fertilizer requirements for phosphate rock and potash as well as the apparent consumption (not adjusted for exports) of two leading industrial chemicals, phosphoric acid and sulfuric acid.

The projections of high, medium, and low industrial consumption levels of phosphate rock and potash are in accord with the appropriate high, medium, and low projections of the FRB index of nondurable manufactures [1]. Also, the forecasts for domestic use of sulfur are consistent with appropriate projections of the FRB index of total industrial production. In addition, projections of agricultural uses of these minerals have been related to projections of the likely levels and the probable effects of farm earnings and of several measures of absolute and relative fertilizer prices.

U.S. export prospects for these minerals will be determined largely by world fertilizer markets. The ability or willingness of the United States to furnish large quantities of these raw materials on credit to the rapidly expanding fertilizer industries in the developing nations of Latin America, Africa, and southern Asia will be a particularly relevant factor. Finally, U.S. capabilities and intentions regarding the export of crude sulfur and potash will be dependent on the ability of the United States to import large quantities of these raw materials from Canadian and Mexican producers at relatively attractive delivered prices. Barring unforeseen technological innovations or geological discoveries of major importance, imports of potash should continue to exceed exports.

Phosphate Rock

Approximately three-fourths of the phosphate rock consumed annually in this country is used for agricultural purposes, and all but 2 percent of this is used for fertilizer. While the commercial term "phosphate rock" describes a wide variety of materials containing commercially important

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quantities of phosphates, mainly calcium phosphates and calcite, the industry expresses consumption and other statistics in terms of quantities of the chemical compound phosphorous pentoxide (P_2O_5). The phosphorous pentoxide content of commercial fertilizers consumed in the United States increased from 1948-50 through 1963-65 at an average compound annual rate of 3.4 percent. Growth during the last half of this period was approximately 3.8 percent.[1]

Statistical analysis indicated that at least 95 percent of the annual variation in phosphorous pentoxide used in fertilizers during 1948-65 was explained by three variables. Most of the moderate increase in consumption was related to an index of total deposits in country banks serving leading agricultural areas. This indicator logically reflected both borrowing power and retained earnings of agricultural producers. Since the mid-fifties, increased use was encouraged by the relatively favorable price level of all fertilizers relative to other crop and livestock production costs. Finally, consumption probably was curtailed by the gradual but persistent increase in phosphate rock prices relative to quotations for potash during the period.

Fertilizer technology certainly contributed to the growth of phosphate consumption since the mid-fifties. The newer high-analysis phosphatic fertilizers are much more efficient carriers of phosphorous pentoxide in forms which are available to growing plants. Widespread adoption of ammonium phosphate fertilizers, which can contain 18 percent nitrogen and 46 percent available phosphorous pentoxide by weight, would certainly increase phosphate consumption. Additional technological developments which would generate unprecedented domestic demand include possible use of phosphates in areas where other limiting factors, such as lack of certain minor nutrients, currently prevent satisfactory yield response to fertilizers containing high amounts of phosphorous pentoxide.

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[1] Statistics compiled by the U.S. Bureau of Mines [7] for the same period indicate that sales of phosphate rock for agricultural purposes increased at a 4-percent compound rate. However, this series is not adjusted for all inventory changes. It includes at least some consumption for poultry and livestock feed, and includes other agricultural chemicals, transportation, and mixing losses. Also phosphorous pentoxide contained in at least some mixed fertilizer exports was probably included in these domestic sales.

Consumption of phosphate rock for nonagricultural purposes has increased rapidly during the past 20 years. The growth rate from 1948-50 through 1963-65 was 9.4 percent compounded annually, although the rate since 1955 has been only about 5 percent per annum.[2] Phosphate rock, after decomposition into either elemental phosphorus or phosphoric acid, has diverse industrial uses. Regression analyses indicated that 95 percent of the annual variation in the consumption of phosphorous pentoxide for industrial purposes between 1948 and 1965 was associated with similar changes in the FRB index for industrial chemicals [1]. During this period, a rise of about 6.5 points in the index was associated with a 1-percent increase in phosphorous pentoxide used by industry.

For chemical and other reasons, nearly all raw phosphate rock is first decomposed into various phosphorous-carrying materials which are then either used directly as animal feed supplements and fertilizers or are transformed into a wide variety of fertilizers and other agricultural and industrial chemical products. Various methods have been developed for reducing phosphate rock; selection of the process depends partly on the end use or product to be manufactured. Alternate methods of acid treatment (acidulation) of the raw rock enable processors to substitute other acids for sulfuric acid. Treatment by sulfuric acid has been the customary method of producing most phosphoric acid as well as the primary source of available phosphoric pentoxide in many mixed fertilizers, including normal superphosphate (figure 1).

Most phosphate rock is reduced to phosphoric acid before it is manufactured into agricultural and industrial products. Phosphoric acid can be produced by several methods (figure 1). The lower grade acid produced by the process of reducing rock with sulfuric acid generally lacks the high-purity characteristics demanded by industrial (food, chemical, and drug) users. Therefore, most acid made by this process is used in the production of triple superphosphate and other highly concentrated fertilizer salts. However, recent changes in fertilizer technology have suggested that more higher grade acid produced from elemental phosphorus is used in the manufacture of agricultural chemicals, including liquid fertilizers.

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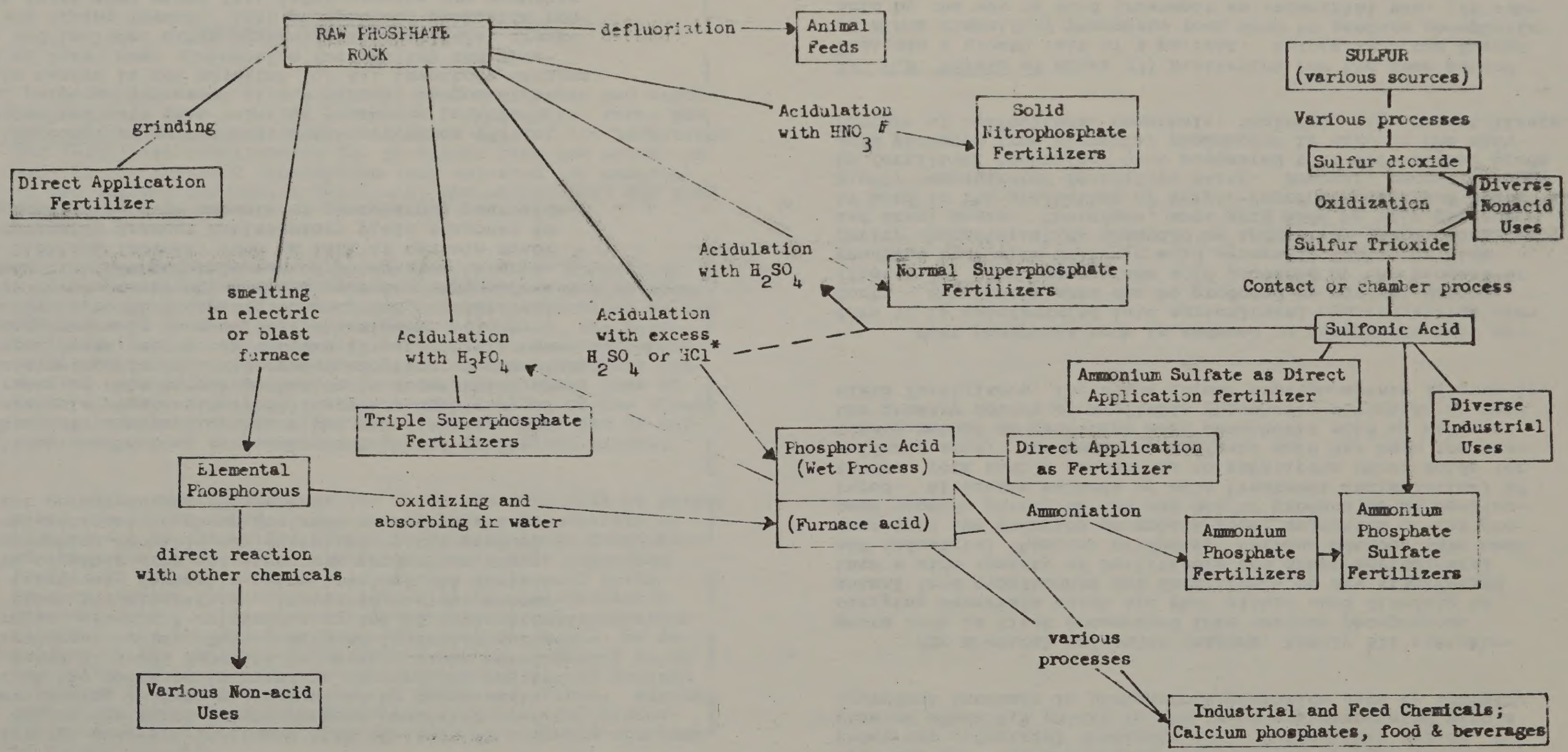
[2] U.S. Bureau of Mines [7] statistics for the same period indicate a growth rate of 8 percent. Before 1955 the Bureau of Mines classified phosphate rock used to produce phosphoric acid by the wet or acid treatment as industrial use. In subsequent years, to show that it was used to produce triple superphosphate fertilizer, it was classified as an agricultural

Figure 1. ALTERNATE PROCESSES FOR DECOMPOSING RAW PHOSPHATE ROCK INTO VARIOUS AGRICULTURAL AND INDUSTRIAL PRODUCTS, AND INTERRELATIONSHIPS BETWEEN PHOSPHATE ROCK AND SULFURIC ACID IN FERTILIZER MANUFACTURING.


RAW PHOSPHATE ROCK
defluoriation
Animal Feeds
grinding
Direct Application Fertilizer
Acidulation with HNO3 #
Solid Nitrophosphate Fertilizers
SULFUR (various sources)
Various processes
Sulfur dioxide
Diverse Nonacid Uses
Oxidization
Sulfur Trioxide
Contact or chamber process
Acidulation with H2SO4
Normal Superphosphate Fertilizers
smelting in electric or blast furnace
Acidulation with H3PO4
Acidulation with excess H2SO4 or HCl*
Sulfonic Acid
Ammonium Sulfate as Direct Application fertilizer
Diverse Industrial Uses
Triple Superphosphate Fertilizers
Elemental Phosphorous
oxidizing and absorbing in water
Phosphoric Acid (Wet Process)
(Furnace acid)
Direct Application as Fertilizer
Ammoniation
Ammonium Phosphate Fertilizers
Ammonium Phosphate Sulfate Fertilizers
direct reaction with other chemicals
Various Non-acid Uses
various processes
Industrial and Feed Chemicals; Calcium phosphates, food & beverages

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[*] Use of HCl has only limited commercial application with current technology. Phosphoric acid produced by HCl process is suitable for higher-grade uses, but it costs more to make.

[#] This process also can produce phosphoric acid, which is recovered by solvent extraction.

From 1948-50 to 1963-65, Bureau of Census statistics [3] for phosphoric acid production, in terms of phosphorous pentoxide content, indicated a growth rate of 13.4 percent compounded annually, a rate which is noticeably higher than the annual increases in phosphorous pentoxide consumption by either agriculture or industry. An increasing proportion of all phosphate rock used in the United States is consumed in the production of this chemical, or is exported as phosphoric acid. The statistics for the period 1963-65 indicate that phosphoric acid production contained the equivalent of 57 percent of the phosphorous pentoxide content of phosphate rock sold or used by phosphate mines. The comparable proportion in 1954-56 was 33 percent.

The relationship between phosphoric acid production and the FRB index of production for industrial chemicals was examined for the period 1948-65. This indicator accounted for 99 percent of the annual variation in phosphoric acid production. The relationship was linear: a one-point increase in the index was associated with an increase in production of nearly 21,000 short tons of phosphoric acid, expressed as 100-percent phosphorous pentoxide.

Projections of Domestic Phosphate Rock Consumption in 1980

Industrial use of phosphate rock is likely to increase from the 1963-65 average of 1.35 million long tons, phosphorous pentoxide content, to slightly more than 2 million tons by 1980 (table 30). The high and low projections are 2.03 million and 1.93 million long tons, respectively, on the stipulations of higher or lower levels of output for nondurable manufactures. These gains imply annual growth rates of 2.6 percent and 2.3 percent, respectively, considerably lower than the historic growth rate attained since 1955 (5 percent).

While production of all industrial chemicals is stipulated to grow at annual compound rates between 6.4 and 5.9 percent during the next 15 years, phosphate rock used by industry should be only 50 percent above the 1963-65 requirements by 1980. Since 1955, use of rock phosphate for industrial purposes has increased at a slower rate than has the production of all industrial chemicals.

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use. Growth rates since 1955 for both RRNA and the Bureau of Mines series agree.

Table 30. Domestic Consumption of Phosphate Rock, Potash, and Sulfur by Principal End Use, 1965 and Projected 1980 and 2000

Commodity and End Use	Unit	1965 (Actual)	1980			2000		
			Low	Medium	High	Low	Medium	High
Phosphate Rock (P_2O_5 content)								
Agricultural uses:								
Current fertilizer technology....................	Tnou. long tons	3,642	4,659	5,028	5,237	6,170	7,035	7,248
Major technological advances assumed..........	do.	--	--	--	9,631	--	--	13,500
Industrial uses.............	do.	1,471	1,934	2,005	2,029	2,434	2,558	2,631
Total..................	do.	5,113	6,593	7,033	7,266 11,660[a]	8,604	9,593	9,879 16,131[a]
Potash (K_2C equivalent)								
Agricultural uses...........	Thou. short tons	3,260	4,378	4,616	4,732	4,742	5,413	5,550
Industrial uses.............	do.	219	433	478	494	881	1,054	1,172
Total....................	do.	3,479	4,811	5,094	5,226	5,623	6,467	6,722
Sulfur (elemental sulfur content)								
Quantity used to manufacture sulfuric acid[b]............	Thou. long tons	6,697	13,020	14,216	14,636	23,715	28,096	31,084
All other uses[c]............	do.	1,296	773	719	700	294	97	1,636
Total....................	do.	7,993	13,793	14,935	15,336	24,009	28,193	32,720

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a/ The higher of the two totals represents industrial use plus agricultural use under stipulation of major advances in fertilizer technology. The lower projection is consistent with agricultural use projections based partly on current levels, or gradually improved, phosphatic fertilizer technologies.

b/ Actual or projected production of sulfuric acid (100 percent), thousand short tons times 0.26948.

c/ Calculated as residual between actual or projected total consumption of sulfur and sulfur consumed to make sulfuric acid.

Source: 1965 data from [3, 7, 9].

Fertilizer consumption of phosphate rock in 1980 is projected at 5.03 million long tons, phosphorous pentoxide content, in line with assumptions associated with the medium projections of GNP and the most likely values for fertilizer price relatives (table 30). Under the assumption of low GNP, domestic agricultural use should rise from a 1963-65 base of 3.5 million long tons to approximately 4.7 million by 1980. Under stipulations of high GNP and favorable price ratios, at current levels of fertilizer technology the domestic use of fertilizer is estimated to increase by 2.4 percent compounded annually, to about 5.2 million long tons in 1980.

The foregoing projection stipulated that current fertilizer technology would be improved only modestly in the foreseeable future. However, major breakthroughs in phosphatic fertilizer technology are distinctly possible by 1980, and are quite probable by the year 2000. These improvements should increase significantly the response of grains and soybeans to phosphatic fertilizers on many soils, including some on which phosphatic fertilizers are not used today. Aggregate crop production might not change substantially under these circumstances, but the amounts of phosphorous pentoxide applied as plant food almost certainly would increase sharply, both absolutely and relative to the quantities of nitrogen and potash used.

In view of such major technological breakthroughs, it is projected that phosphorous pentoxide consumption in fertilizers could increase to 9.6 million long tons by 1980 (table 30). This expanded demand implies an annual growth rate of 6.5 percent, well above 1956-65 average (3.8 percent).

The production of phosphoric acid for both industrial and agricultural end uses has tended to increase at a constant rate with the production of all industrial chemicals. Furthermore, annual growth of phosphoric acid production during the past 20 years indicated that progressively larger percentages of all phosphate rock used was converted into this acid before it was manufactured into various industrial or agricultural chemicals. By 1980, phosphoric acid plant capacity might easily exceed the projected domestic use of phosphate rock, unless the highest projection, contingent upon new fertilizer technologies, is accepted as the most likely demand level. However, it was assumed that most excess acid plant capacity would be used to reduce part of the exports of raw phosphate rock into processed phosphates (table 31).

Table 31. Exports and Total Disappearance of Phosphate Rock and Processed Phosphates, Potash, and Sulfur, 1965 and Projected 1980 and 2000

Commodity	Unit	1965 (Actual) a/		1980						2000					
		Exports	Total use	Exports			Total consumption b/			Exports			Total consumption b/		
				Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
Phosphate rock (P_2O_5 content), total															
Current fertilizer technology..	Thou. long tons	2,065	7,178	5,000	6,210	6,800	11,593	13,247	14,066	14,300	16,500	18,100	22,104	26,903	27,979
Major advances in technology...				--	--	--	--	--	18,460	--	--	--	--	--	34,231
Of which: Phosphoric acid c/..	do.	--	3,433	3,558	3,027	1,000-2,586 e/	8,042	9,005	9,343	10,965	18,148	8,619-14,558 e/	17,676	21,398	23,943
All phosphate rock reduced to phosphoric acid d/	Percent	--	48	71	49	15-38 e/	69	68	51-66 f/	77	80	48-80 e/	77	82	70-85 d/
Potash (K_2O equivalent)..........	Thou. short tons	648	4,127.2	370	1,300	1,600	5,681	6,394	6,826	2,150	2,330	8,170	7,773	8,797	14,892
Sulfur...........................	Thou. long tons	2,651	10,644.0	3,815	4,225	4,700	17,608	19,160	20,036	4,450	6,400	10,200	28,459	38,393	42,920

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a/ Phosphoric acid equivalent of total exports of all processed phosphates was not readily calculable.

b/ Includes domestic consumption (projections from table 1).

c/ Total phosphoric acid consumption = Production estimate derived from regression equation, Y= 20.81455 (FRB index for industrial chemical production) - 423.46 and then converted from short to long tons.

d/ Estimated domestic use was deducted and the remainder allocated to exports. These percentages of total domestic phosphate rock consumed were assumed to be reduced to phosphoric acid before being used to make agricultural or industrial chemicals: 1980: 68 percent, 85 percent, and 93-86 percent; 2000: 78 percent, 80 percent, and 95 percent, respectively.

e/ The range in high projections for processed phosphates exports results from different percentages of assumed phosphoric acid plant capacity needed to process phosphoric acid for domestic use. The higher of the two projections of total phosphate rock use and assumes that current levels of phosphatic fertilizer technology will remain relatively unchanged in the foreseeable future. Under such circumstances, higher relative and absolute quantities of phosphate rock will be converted into processed phosphates before being exported.

f/ The ranges in projected percentages of phosphate rock reduced to phosphoric acid before being manufactured into various chemicals results from two different total projections of total phosphate rock consumption. The lower percentage is consistent with the higher projection of phosphate rock consumption and would imply that phosphoric acid plant capacity, at the projected level, would restrict the relative amount of rock which is first reduced to phosphoric acid (figure 1).

Source: 1965 data from [3, 7, 9]

Projections of Domestic Phosphate Rock Consumption in 2000

Between 1980 and 2000, industrial use of phosphate rock in the United States is projected to increase at a compound annual rate of 1.3 percent, conforming with high projections of industrial production, and by 1.2 percent a year, conforming with the medium or low projections of industrial production (table 30). Fertilizer use is projected to increase at a slightly higher rate between 1980 and 2000 than is implied for the industrial consumption of phosphates. Assuming both high GNP and major improvements in phosphatic fertilizer technology, agricultural use is projected to increase to 13.5 million long tons, which implies an annual growth rate between 1980 and 2000 of 1.7 percent per year from the highest levels projected for 1980 (table 30).

If it is assumed that significant improvements in phosphatic fertilizer efficiency will not occur during the next 30 years, then domestic agricultural use of phosphatic rock is projected to increase between 1980 and 2000 by 1.9 percent per year, based on the high GNP projection, and by 1.4 percent per year, based on the low projection (table 30).

Total domestic use of phosphate rock in 2000 is estimated to be from 83 percent to 110 percent above 1963-65 requirements, given fertilizer practices prevalent today. With radically improved fertilizer technology, total use of phosphates could exceed current levels of consumption by 245 percent.

Projections of Phosphate Rock Exports, 1980 and 2000

Dynamic increases in sales abroad have been achieved by exporters of U.S. phosphate rock and processed phosphates since 1954. Phosphate rock exports increased from 1954-56 through 1964-66 at an average compound annual rate of 9.2 percent. This growth trend was remarkably persistent throughout the entire 12-year period, and annual exports since 1962 have increased even more rapidly.

Most requirements of less developed countries during the next few decades will be met by importing raw materials (rock phosphate and sulfur). Development of phosphate rock mines overseas will subsequently reduce dependence on U.S. and North African supplies. New plant capacity to reduce raw rock into available phosphorous pentoxide will be erected, but phosphoric acid production in developing countries will not increase as fast as the consumption of phosphates. Their imports of processed phosphates may increase at faster rates than anticipated, if shortages in shipping space or improvements in technology of production, storage, or transportation of concentrated acids result in economic advantages to the developed countries, which would lead to an increase in the exports of concentrated phosphatic fertilizers.

U.S. exports of phosphate rock and processed phosphates are projected to increase approximately 180 percent before 1980, according to the low assumption. Exports then should exceed 5 million long tons, compared with the 1963-65 average of 1.8 million long tons, phosphorous pentoxide content (table 31). The high projection implies an annual increase of 9.5 percent compounded, approximately that attained historically since 1954. The medium estimate that exports will reach 6.2 million tons by 1980 implies a similar growth rate initially, but assumes that annual gains will decline to 5 percent after 1975.

Since 1954, U.S. exports of phosphates have increased at approximately the same compound annual rate as world fertilizer consumption. Since the latter is projected to continue to increase at an annual rate exceeding 10 percent, all projections for medium and low exports appear easily attainable. It could be demonstrated that medium level exports would be reached if U.S. foreign shipments only retained their historic shares of leading markets. Large exports from North African countries probably will lower annual rates of expansion of U.S. sales in the 1970's. Prospects for important new phosphate mines in other parts of Africa, and possibly in South America and Australia, are recognized. Such potential competitors could displace U.S. phosphates in at least several markets in the 1980's.

Between 1980 and 2000, U.S. exports of rock phosphate and processed phosphates are forecast to increase at a somewhat slower rate than during the 1970's (table 31). Shipments should increase between 4.5 and 5.5 percent per year, consistent with the low and high estimates. At the end of this century, annual exports of U.S. phosphates are projected to have increased about eight times (medium projection) the average foreign sales attained in 1963-65 (table 31). However, by 2000 consumption of fertilizer in the less developed countries of the free world should equal that of North America, Western Europe, and Japan and might total over 43 million metric tons of phosphorous pentoxide annually.

Potash

The term potash as used by the mining industry and in this report means the potassium oxide content, or K_2O equivalent, of potash minerals[3] or crude potash salts. Approximately 95 percent of the potash consumed in this country is used by domestic agriculture or is processed by fertilizer manufacturers and exported as a potassium fertilizer material and in mixed fertilizers. The estimates indicate that the domestic consumption of potash as fertilizer increased at a compound rate of 7.2 percent annually from 1948-50 through 1963-65. Twenty years ago, U.S. fertilizer manufacturers used twice as much phosphorous pentoxide as potash. Now, this ratio has narrowed to about 1.1 to 1.

Nearly all (98 percent) of the annual variation in potash consumption in fertilizers during 1948-65 can be explained by two factors. Most of the growth in demand was associated with the aggregate increase in buying power of farmers and agricultural service industries and with the favorable price ratio of fertilizers compared with other farm production costs, particularly since the mid-fifties. Although marked price reductions of potash in the early sixties may not have been important in increasing consumption, more recent price increases have probably stimulated production by potash producers, and increases in supplies have been absorbed readily by the rapidly growing fertilizer industry.

Detergent, soap, glass, and ceramic manufacturers use about 60 percent of the 6 percent of domestic potash not used by agriculture. Textiles, dyes, chemicals, and drugs account for the balance. These industries increased their consumption of potassium compounds at an annual rate of 6.4 percent from 1949-51 through 1963-65. Nearly all the annual variation in potash used by these industries during this 17-year period can be explained by a composite index (33-percent weight attached to the FRB index of production of clay, glass, and lumber, and 67 percent weight to the FRB index of total nondurable manufactures).

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[3] Potash minerals are primarily potassium chlorides and potassium sulfate. Potash fertilizer materials include potassium carbonate from wood ashes and potassium in organic form in tobacco stems. Projections allow for these sources which are of minor commercial importance in mixed fertilizers.

Projection of Domestic Potash Consumption in 1980

The consumption of potash in commercial fertilizers is forecast to increase to 4.6 million short tons in 1980, based on the medium GNP projections and the estimates of the most likely price relationships (table 30). The increased disappearance projected by the high estimate implies a growth rate of 2.8 percent compounded annually. The corresponding rate of growth consistent with the low projection of GNP is 2.3 percent.

These implied overall growth rates are significantly lower than the 7.2-percent annual increase in sales which potash fertilizer materials have maintained since 1948. However, marginal increases in annual potash used in domestic agriculture in the future should require greater rather than constant increases in GNP. In fact, the attainment of the medium and high consumption projections, representing total increases up to 53 percent more than used in 1964, assume that while fertilizer prices in 1980 will be considerably cheaper relative to other agricultural input prices than in 1964, potash raw material prices will rise sufficiently to insure that adequate supplies for both domestic use and export are processed and sold.

Industrial use of potash is projected to increase between 1965 and 1980 at a compound annual rate of 5.8 percent, based on the medium industrial production, and at 6 percent and 5.1 percent per year, respectively, given the alternative high and low projections of nondurable manufacturing output (table 30). The overall rates of growth implied by these projections are somewhat lower than the 6.4 percent achieved in the 1949-65 period. However, industries requiring potash chemical compounds should continue to increase their consumption at a constant marginal rate, and output of clay and glass manufacturers and other potassium-using industries is forecast to increase at corresponding annual rates of 7.8 to 8.8 percent through 1980. In spite of the differences in projected growth rates of agricultural and other industrial uses, however, only about 10 percent of the potash consumed in 1980 is likely to be used for nonagricultural purposes.

Projections of Domestic Potash Consumption in 2000

Consumption of potash in fertilizers between 1980 and 2000 is projected to increase by 0.8 percent, compounded

annually, based on the high and medium projections of GNP, and by only 0.4 percent per annum, based on the low projection. Again, high and medium projections assume both favorable selling prices for potash producers and relative low fertilizer costs to farmers (table 30).

Domestic consumption by other industries is projected to increase between 1980 and 2000 at an annual compounded rate of 4.1 percent, consistent with the medium projections of industrial projection. Corresponding rates of growth, implied by projected high and low levels of industrial production, are 4.4 and 3.6 percent, respectively, per year (table 30).

During the next 30 years, total domestic potash use by fertilizer manufacturers and other industries is projected to increase to between 181 percent and 198 percent of 1963-65 requirements. Industrial consumption in 2000 will constitute 16 percent of the total demand for potassium compounds, compared with a corresponding figure of 6 percent in 1965.

Projections of Potash Exports, 1980 and 2000

Potash exports increased at a compound annual rate of nearly 17 percent during the period 1954-66. Since 1960, however, growth has slowed to approximately 6.3 percent, and the pattern of change between consecutive years has become highly irregular. Since 1962, the United States has been a net importer of potash.

The unique role of the United States as both a leading importer and exporter of potash should not be regarded as transitionary. Delivered costs of imported potash in many important domestic agricultural regions have been lower than delivered costs for domestic supplies shipped from the Southwest. Potassium salts from U.S. mines have been highly competitive in foreign markets, however.

Potash fertilizer materials shipped from North America and Northern Europe will constitute the bulk of world exports in the foreseeable future. Consumption of potash in less developed countries will lag behind consumption of phosphorous pentoxide until new sources of potassium oxide cause this plant nutrient to have a comparative delivered-price advantage, or until agricultural experience with fertilizers identifies potassium rather than nitrogen or phosphorus as the limiting factor in crop production. In either of these eventualities, consumption in the less developed countries should increase as rapidly as it did in the United States during the last few decades.

Between 1967 and 1980, U.S. exports of potash fertilizer materials almost certainly will not continue to grow at the extremely high annaul rates attained during the late fifties and early sixties (16.8 percent for the entire 1954-66 period, but only 6.3 percent since 1960). The medium estimate is that foreign shipments will reach levels of slightly more than 1.3 million short tons, potassium oxide equivalent, by 1980 (table 31). This projection implies that exports will increase approximately 5 percent each year from a 1964-66 average of slightly more than 0.62 million tons.

The low projection for 1980 (0.9 million tons) stipulates that significant quantities of potash from increased Canadian production may be sold overseas rather than shipped into the north central United States (table 31). Canadian potash production by 1970 should exceed 3 million tons [6], and historical extrapolations of exports to the United States imply that the domestic fertilizer industry would absorb about 2.1 million tons. If as much as half this potash were shipped direct from Canada to other established markets, the impact on U.S. imports would be quite apparent.

Moderately larger quantities of potassium oxide will be used each year in the developing nations. Barring the subsequent discovery and development of important new potash deposits, practically all of these requirements will be imported, presumably from Europe and North America. By 1980, these demands should be around 4.4 million tons per year. The high forecast is that U.S. exports by 1980 will reach 1.6 million tons, or 257 percent of the 1964-66 average shipments (table 31). This prediction is conditional upon the assumption that U.S. exporters retain approximately their 1963-64 share of world potash trade (about 10 percent). However, most U.S. potash sales (80 percent) have been to developed countries, and potash exports from this country should not increase as rapidly as total world trade in fertilizers during the next 15 years.

Between 1980 and 2000, U.S. exports of potassium salts are forecast to increase between 3 and 8.5 percent each year.

This sizable range in growth rates reflects the magnitude of the uncertainties concerning potash requirements in the developing countries, assuming that crop yields during the next 15 year will increase, roughly 2.6 percent each year, on the average.

The medium estimate is that exports will continue to rise moderately, increasing nearly 0.5 million tons each decade and exceeding 2.3 million tons by 2000 (table 31). This gain should be easily attainable, barring significant changes in the world fertilizer trade which would disrupt established markets for U.S. potash fertilizers.

Much higher exports can be projected for 2000, provided that no new major sources of potassium oxide are developed in locations which would materially alter current patterns of world trade in potash materials. In this case, the current U.S. share of total exports of free world markets would suggest exports at the end of this century of 6.6 million short tons, all except 2 million of which would be shipped to Southern Asia, Latin America, and Africa. Then, if a modest shift in fertilizer content nutrient ratio is assumed,4/ U.S. exports of potassium fertilizer materials by 2000 would approach 8.2 million short tons, potassium oxide equivalent, or more than 13 times the 1963-65 average (table 31).

On the other hand, the low projection for exports in 2000 is only slightly lower than the medium forecast. This forecast of slightly more than 2.1 million short tons, potassium oxide equivalent, implies a compound growth rate of 4.7 percent per year from the low 1980 estimate (table 31). This comparatively modest estimate is consistent with one of several plausible assumptions which should cause a decline in relative importance of U.S. supplies in the huge prospective world market in potash fertilizers. World resources of potassium minerals are extremely large. Unless imports continue to exceed the foreign sales from U.S. mines, known U.S. reserves of high-grade soluble potassium compounds would not enable exporters to acquire a large share of the prospective world potash trade during the last several decades of this century.5/

4/ $N:P_2O_5:K_2O$ from 4:2:1.2 to conform more widely with current ferilizer practices in this country (4:2:1.6).

5/ Several real prospects should be recognized, anyone of which would cause U.S. exports to be curtailed in the next

Sulfur

Apparent total U.S. sulfur consumption (not adjusted for exports) increased at a compound annual rate of 3.3 percent between 1948-50 and 1963-65. This growth was remarkably constant until the 1960's, when consumption began to increase at a compound annual rate of at least 5 percent. However, domestic sales from the leading source of supply, sulfur deposits mined by the Frasch (hot water) process, remained quite constant through 1964. During the past 20 years, industry has become progressively more reliant on sulfur supplies recovered from refinery gases, imports of native sulfur from Mexico, and recovered sulfur from Canada.

Countless uses in many leading industries have been developed for sulfur, and sulfur consumption in any country is often regarded as a reliable benchmark of total chemical production, or even of total industrial activity. The statistical analysis confirms this relationship: about 96 percent of the annual variation in sulfur consumption between 1948 and 1965 was explained by the level of the FBR index of total industrial production. Annual consumption of sulfur from all sources increased or decreased approximately 45,000 long tons with each one-point change in the index.

Most of the sulfur used in this country is converted into sulfuric acid, and then is consumed in the manufacture of fertilizers (superphosphate and ammonium phosphate), industrial chemicals, paints, pigments, petroleum products, and many other products. Industry statistics on the final end uses of sulfur are not complete, but they are adequate to allow the identification of significant trends among competing industries. Sulfuric acid accounted for 85 percent of sulfur used in 1964, compared with 78 percent 10 years earlier. In 1964, 40 percent of sulfuric acid was used by fertilizer manufacturers, compared with 36 percent in 1954. Industrial chemicals required 20 percent in 1964, compared with 25 percent in 1954, and whereas petroleum refining used about 10 percent of sulfuric acid production in 1954, in 1964, petroleum refining demand for sulfuric acid was insignificant.

Regardless of changes in use patterns, sulfuric acid production in this country has been increasing at a more rapid rate than total sulfur consumption. From 1948-50 through 1963-65, production of sulfuric acid increased at an annual rate of 4.4 percent, compounded. This growth rate declined to 2.5 percent during the late fifties, and then rose sharply during the 1960's to approximately 7.5 percent per year. Production during this 18-year period was highly correlated with the FRB index of total industrial production, which explained 98 percent of the variation in production of this chemical. Each one-point change in the production index was reflected in a change of approximately 173,000 short tons of pure sulfuric acid produced.

Sulfuric acid and phosphoric acid act as either complementary or competitive (substitute) inputs in the manufacture of phosphatic fertilizers. Major changes in fertilizer production technology during the past 20 years have been instrumental in increasing the consumption of both these chemicals. Many interrelationships between these two chemicals in fertilizer manufacturing are shown in figure 1.

Projections of Domestic Sulfur Consumption in 1980

Total sulfur consumption should continue to grow at a constant rate in accord with increases in total industrial production in this country. Consumption of sulfur from native and other forms, including imports, is projected to rise to over 14.9 million tons, elemental sulfur equivalent, on the assumption of the medium level of total industrial production (table 30). Under alternative high and low projections of industrial production, sulfur consumption is projected to rise from a 1963-65 average base of 7.3 million tons to approximately 15.3 million and 13.8 million tons, respectively (table 30). These forecasts imply annual growth

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40 years: (1) Depletion of known domestic reserves of soluble potassium compounds. Our reserves are much smaller, relative to annual consumption, than any of the other six major producing countries. (2) Failure of the domestic potash industry to discover new sources of potassium, either through technological breakthroughs which would permit commercial use of vast insoluble potassium-bearing minerals, or through significant expansion of known reserves. (3) Major sources of potassium fertilizer materials may become available through development of deposits nearer prospective major consuming areas, or of technologies permitting the extraction of potassium oxide from sea water at competitive prices. (4) The USSR may offer huge quantities from her resources, either on barter terms or through commerical transactions with these developing nations.

rates ranging from 4.8 to 4.1 percent, which are similar to the rate at which sulfur consumption grew during the 1960's, but which are somewhat higher than the average 3.3 percent per year increase in apparent consumption since 1948.

Sulfuric acid production is also projected to increase at a constant rate in accord with increments in total industrial production. Approximately 95 percent of the sulfur consumed in 1980 may be used to produce sulfuric acid, in contrast to approximately 85 percent of current sulfur production (table 30).

Projections of Domestic Sulfur Consumption in 2000

Between 1980 and 2000, on the stipulations of either high or medium levels of total industrial production, sulfur use is calculated to nearly double, increasing at annual compound rates of 3.9 and 3.2 percent, respectively (table 30). Consumption projected on the basis of low industrial production would rise to 24 million tons by the year 2000, an increase which implies a growth rate over the 20-year period of 2.8 percent per year. Apparent total domestic disappearance of sulfur between 1964 and 2000 is projected to increase between 330 and 450 percent. Between 1980 and 2000, the production of sulfuric acid is projected to increase at approximately the same rates implied for sulfur.

Projections of Sulfur Exports, 1980 and 2000

U.S. sulfur exports during the past 20 years have been limited by the known reserves of native sulfur deposits, which are considered adequate for about 40 years at recent rates of extraction. Also, competition from Canadian and French recovered sulfur and the Mexican sulfur deposits prevented significant growth in foreign sales of U.S. crude sulfur until 1963. Between 1963 and 1965, sulfur exports increased by 62 percent. In 1966, sulfur exports declined. At the same time, leading world producers curtailed their foreign sales, sulfur prices rose, and many of the numerous sulfur-using industries here and abroad found that supplies of this essential element were scarce relative to huge demands generated by record world industrial production. The decline in the quantity of sulfur available to satisfy world markets is probably temporary. World production and U.S. trade can be expected to increase in response to increasing sulfur prices.

It is assumed that the short-term outlook for sulfur consumption in this country will preclude sizable increases in U.S. exports of crude native sulfur until after 1970, but that in the 1970's higher sulfur prices will have encouraged technological developments which will enable the United States to become less dependent on its own exportable Frasch (native) sulfur supplies to sustain domestic industrial production. It is further assumed that no major breakthrough in sulfur technology will occur between now and 1980. Instead, the combination of higher prices and temporary dislocations of supplies will cause sufficient development of larger supplies of recovered sulfur and/or pyrites to release additional crude native sulfur for export. The export projections for 1980 would probably not be considered by the sulfur industry as excessive, based on the best information available about probable reserves 10 or 15 years hence. Native sulfur has dominated U.S. export trade since the mid-fifties, and it is assumed that practically all the sulfur exported during the next 10 or 15 years will be crude Frasch-process material from Gulf ports.[6]

Sulfur exports most likely will increase irregularly between 1966 and 1980 at an overall rate of 3.9 percent compounded annually. The medium projection is based on the assumption that growth through 1970 would increase 2 percent per year, and that growth during the 1970's would parallel increased shipments of phosphate rock during the comparable period. Exports are therefore expected to reach a level slightly higher than 4.2 million long tons, sulfur equivalent, in 1980. Projections of a high of 4.7 million tons and a low of about 3.8 million tons imply average compound growth rates of 4.6 percent and 3.0 percent per year, respectively (table 31).

During the next 15 years, export demand for U.S. crude native sulfur will be dominated by the size of contemporary shipments of phosphate rock exports. Under current levels of technology, shipments of crude sulfur and raw rock phosphate from U.S. Gulf ports constitute attractive sources of raw materials for the reduction of superphosphatic fertilizers in many areas where fertilizer capacity is currently being expanded. It is assumed that normal superphosphate will be the most common phosphorous material in many overseas markets during the next 15 years, and that transportation and storage considerations will continue to cause overseas buyers to prefer to purchase raw materials here and process the rock into phosphatic fertilizers in their own plants, instead of ordering highly concentrated phosphoric acid.

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[6] Several years ago, before the sizable increase in U.S. exports, potential reserves of U.S. Frasch sulfur were judged to be adequate to last until 2000, at the current rate of production.

Between 1980 and 2000, the demand for U.S. sulfur exports will continue to be determined largely by the needs of foreign manufacturers of phosphatic fertilizers. An important factor in determining what part of the total demand will be met by sulfur-containing phosphatic materials will be whether economic crop production in less developed nations requires that important amounts of sulfur be added as a plant nutrient to fertilizers.

The projections of high and medium exports in 2000 assume that domestic supplies of sulfur will be ample relative to prospective needs. The low projection is consistent with the possibility that sulfur-deficient developing countries will be producing significant quantities of their own sulfur needs by 2000.

U.S. exports of sulfur between 1980 and 2000 are projected to increase at moderately lower rates than during the preceding two decades. The medium projection of 6.4 million long tons, sulfur equivalent, is about 150 percent above the 1966 shipments and implies a compound growth rate of 2.1 percent per year from 1980 levels. High and low projections of 10.2 million and 4.4 million, respectively, imply average increases each year of between 3.9 and 0.8 percent (table 31). The highest projection represents probable levels of shipments, if a firm agronomic need is demonstrated for moderate quantities of sulfur in crop nutrition. It also implies that sulfur reserves for domestic industry will be considered ample.

CHAPTER IV

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CHAPTER V

SELECTED METALS AND OTHER NONFUEL MINERALS

The nonfuel metals and minerals considered in this study are those which are of specific interest to the Public Land Law Review Commission because of their importance in the public lands and public land areas. A number of minerals, such as some rare earths, fluorspar, chrome, or cobalt, were excluded either because their future consumption is dependent on strategic factors which cannot be determined, or because they are of relatively minor importance to the economy of the United States. Boron, for instance, was excluded because it is closely connected with military and space programs, and commercial experience with boron is insufficient to provide a base for projections. Silver, of course, is a special case because of its monetary aspects. Although it is an important metal in public land areas and industrial use of silver is growing, the fact that the price was pegged until very recently makes projections very uncertain.

With the exception of sand and gravel, which are largely consumed in the regions where they are produced, all projections were made on a national basis. Projections of exports were made for those commodities which are exported in significant quantities.

The projections of metals consumption presented in this study should be interpreted carefully. They represent quantities that will be consumed if trends in relative prices remain constant or continue to change at rates implicit in the relationships between consumption and the Federal Reserve Board production indexes in the years 1948-65 [4]. Although cross-substitutions of metal for metal, nonmetal for metal, and metal for nonmetal can be expected to occur, the assumption of constant trends in relative prices appears to be reasonable since substitutions tend to occur at the margin; changes in the relative consumption of the several metals will probably not be subject to great variations (e.g., the rate of increase in copper consumption may be less than the rate of increase in the consumption of a copper substitute, but the difference in the rates of increase will not change significantly over the next 35 years). There is no instance of declining consumption of the metals considered in this study over the period 1948-65.

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Consumption, for the purpose of this study, is defined as the disappearance of the commodity at the stage of fabrication where the commodity is in its most homogeneous form; that is, before it becomes incorporated in composite products. The projections include both primary materials (e.g., iron consumed as iron) and secondary materials (e.g., steel), but avoid double counting (e.g., iron used in making steel). Consumption was measured at the first stage of fabrication when data were available; that is, consumption by fabrication rather than production of primary material. However, it was sometimes necessary to use shipments (as distinct from production), as, for example, in steel. Projections of consumption were generally based on trends observed between 1948 and 1965.

Projections of Major Metals

Iron and Steel

Projections of U.S. iron and steel requirements were necessary as a basis for projecting the consumption of such commodities as iron ore and manganese ores. Consumption was defined as the sum of domestic shipments of mill shapes, iron and steel castings, imports of steel mill products and castings, and exports.

The level of consumption of iron and steel is directly related to the level of industrial production in the United States. In projecting iron and steel demand, use was made of the FRB projections [4]. Based on FRB projections, the medium forecasts for 1980 and 2000 are 255.8 and 451.1 million long tons, respectively (table 32).[1]

Since 1948, iron and steel exports have been a declining percentage of total production. Because of foreign

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[1] These projections are high compared with others commonly quoted, e.g., Resources for America's Future [5]. Our figures are more inclusive of all types of iron and steel and contain both imports and exports. Also, our projections do not assume any constraints of supply, and allow for substitution of other products for steel at the same rate as has occurred in recent years. In addition, our figures assume a faster growth of GNP in the future than that in the 1950's which formed a large part of the base.

Table 32. Projected U.S. Consumption plus Export for Selected Metals and Minerals, 1965 and Projected 1980 and 2000

Commodity	Unit	1965	1980			2000		
			Low	Medium	High	Low	Medium	High
Iron and steel	mil. long tons	105.6	246.0	255.8	261.9	417.2	451.1	535.4
Iron ore[a/]								
Domestic consumption[b/]	do.	72.8	194.1	201.7	206.7	329.3	356.1	422.6
Domestic consumption plus exports	do.	132.2	313.5	325.2	333.0	511.6	551.4	650.8
Aluminum	thou. short tons	3,736.2	8,202.7	9,054.7	10,586.4	15,930.2	19,138.5	21,295.1
Copper	do.	2,883.7	4,208.2	4,492.6	4,585.1	6,703.6	7,715.1	8,402.1
Wire mills	do.	1,223.4	1,974.5	2,145.9	2,202.0	3,458.0	4,056.4	4,465.0
Brass mills and other	do.	1,660.3	2,233.7	2,356.7	2,383.1	3,245.6	3,658.7	3,937.1
Lead	do.	1,241.5	1,337.4	1,365.8	1,375.7	1,596.4	1,701.5	1,773.3
Zinc	do.	1,742.1	2,683.3	2,957.2	3,054.4	6,732.9	9,783.2	12,626.7
Magnesium[c/]	do.	83.2	226.0	246.0	254.1	436.0	522.6	581.8
Mercury	thou. flasks	76.5	140.0	152.8	155.9	245.1	288.2	317.6
Manganese ore[d/]	thou. short tons	2,866.1	7,970.3	8,307.6	8,529.1	13,992.3	15,183.9	18,150.6
Nickel	do.	172.1	300.2	327.6	337.1	550.2	651.7	721.0
Molybdenum								
Domestic consumption	Mil. lb.	48.6						
Dom. cons. plus tungsten in steel	do.	51.8	114.8	125.3	128.9	210.6	249.5	276.1
Exports	do.	24.1	50.0	50.0	50.0	100.0	100.0	100.0
Tungsten[e/]	thou. lb.	10.4	22.2	24.4	25.2	42.7	51.1	56.8
Vanadium	thou. short tons	4.7	11.1	12.3	12.8	22.4	27.0	30.1
Diatomite	do.	580.3	1,350.4	1,482.5	1,528.9	2,532.0	3,016.0	3,346.3
Sand, gravel, and crushed stone	Mil. short tons	1,685.7	4,106.4	4,561.6	4,721.3	9,338.5	11,221.8	12,508.8

a/ Iron content. b/ Gross weight. c/ Includes secondary, but excludes exports. d/ Not less than 35 percent manganese. e/ Other than used in steel production.

Source: Data for 1965 from [1, 2, 6, 7].

demands for specialty steel and the establishment of subsidiary outlets by U.S. producers, exports have been projected to increase to a level slightly higher than the 1965 rate. In 1965, 3.3 percent of total U.S. iron and steel shipments was exported. For 1980 and 2000, the percentage is expected to decline, although the tonnage will probably increase modestly. The medium projections of total exports are 3.8 million long tons in 1980 and 4.5 million long tons in 2000 (table 33).

Iron Ore

The projections of iron ore requirements in 1980 and 2000 are made by first estimating the total iron content of ore that would be necessary to produce the total projected consumption of steel. It was assumed that the ore-to-scrap ratio in the production of steel would remain relatively constant. New production (and recovery) techniques have been developed which favor both scrap and ore; it was assumed that these techniques will tend to offset each other and that the ratio will not change over the longer term.

The medium projection of iron ore requirements is 201.7 million long tons for 1980 and 356.1 million long tons for 2000 (table 32).

In order to estimate the amount of ore needed to make the steel that will be produced in the United States, it is necessary to know how much steel will be imported for U.S. consumption. If present trends hold, the United States will be importing almost half its steel by 1985. However, it is difficult to accept the suggestion that the rates of increase over the past 10 years will be permitted to continue. Both for strategic and competitive reasons, the share of imported steel in the U.S. market will probably be limited. Imports in 1966 exceeded 12 percent of U.S. consumption and have elicited strong efforts to restrict them. The projections for iron (table 32) are based on the assumption that steel imports will be limited to 15 percent of U.S. consumption of steel.

Exports of iron ore are estimated in gross weight because the average percentage of iron content of exports is not available. Such exports in 1965 were about 3 million long tons to Canada and 4 million to Japan. Steel industries

Table 33. Export Demand for Selected U.S. Metals and Minerals, 1948-65 and Projected 1980 and 2000

Commodity	Unit	1965	1980			2000		
			Low	Medium	High	Low	Medium	High
Iron and steel.......	Mil. long tons	3.1	3.7	3.8	3.9	4.2	4.5	5.4
Iron ore............	do.	7.1		10.0[a/]			20.0[a/]	
Aluminum[b/]..........	Thous. short tons	341.0	820	905	1,059	1,598	1,914	2,130
Copper[c/]............	do.	50.7[d/]	*	*	*	*	*	*
Lead................	do.	11.5	*	*	*	*	*	*
Zinc................	do.	19.3	*	*	*	*	*	*
Magnesium...........	do.	17.8		50[e/]			100[e/]	
Mercury.............	Thous. flasks	7.5[f/]	*	*	*	*	*	*
Manganese ore........	Mil. short tons	e/	*	*	*	*	*	*
Nickel..............	Thous. short tons	20.9[g/]	*	*	*	*	*	*
Molybdenum[h/].........	Mil. pounds	24.9	63.7	69.4	71.6	117.5	139.4	154.3
Tungsten............	do.	*	*	*	*	*	*	*
Vanadium............	Short tons	*	*	*	*	*	*	*
Diatomite...........	Thous. short tons	114	270.1	296.5	305.8	506.4	603.2	669.3
Sand and gravel......	Mil. short tons	*	*	*	*	*	*	*

* = Less than 1 percent.

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a/ Gross weight.
b/ Includes aluminum pigs, bars, scrap, and shapes and forms.
c/ U.S. expected to be net importer of all forms of copper, with only token exports, except in finished products.
d/ Net exports of copper scrap. U.S. is net importer of other forms of copper.
e/ Exports expected to grow, but at decreasing rate.
f/ Exports unusually high in 1964 (2,575) and 1966 (7,543). Returned to normal (357) in 1966.
g/ Includes scrap, alloys, mill shapes. Exports are almost wholly secondary and reexports, and they vary considerably. No projection attempted because it was considered not significant.
h/ Export demand may not actually be met if supplies become inadequate.

Source: Historical data from [1, 2, 6, 7].

in both countries are expected to expand substantially in the next 35 years, but both have alternative sources of ore. Australia, Malaysia, the Philippines, and South America are providing increasing quantities to Japan. However, the Japanese need will be so great that it is believed that shipments from the west coast of the United States and Alaska will continue to hold a share of the Japanese trade. Thus, the export demand for U.S. ore may be expected to increase at a rate of about 5 percent annually, rounded off to 10 million long tons for 1980 and 20 million for 2000 (table 33).

Aluminum

Consumption of aluminum has risen dramatically in the post-World War II period, from 731,000 short tons in 1948 to 3.7 million in 1965. The use of aluminum has increased steadily, with actual declines in 1958 and 1960 only. The correlation between demand for aluminum and the FRB index of durable goods production is high (.973), and the index was used to project requirements. This gave a medium estimate of 9.055 million short tons in 1980 and 19.139 million short tons for 2000 (table 32). While these figures seem astronomical, they are no more surprising than those for current consumption compared with 1948. Aluminum is only beginning to be used in many fields where it has a promising future. For instance, in the construction business aluminum can be substituted for several million tons of steel in 1980 without any apparent effect on steel demand (about 2 percent of projected steel consumption), but with dramatic results in expanded aluminum demand. In fact, the projections of both steel and aluminum assume that such substitution will continue to take place at a high rate, as over the past 18 years.

Export demand has been a substantial factor in the aluminum industry in the United States. It is projected to continue at 10 percent of output (table 33). The aluminum industry in the United States participates in a worldwide market in which company relationships cut across national boundaries. Aluminum will continue to be exported, although the United States is a net importer by two to one. The exports are increasingly made in shapes and forms, and proportionately less in primary aluminum and scrap.

Copper

The consumption of copper in the United States has been erratic in the post-World War II period, more from interference

with supply than from changes in demand. Strikes and political uncertainties have created periodic but irregular shortages which, in turn, have necessitated substitutions, both temporary and permanent. Most of the variation falls on the brass mills, because there is little room for substitution or postponement of consumption in the wire mills. Thus the coefficient of correlation between the FRB index of industrial production and copper consumption in the wire mills is high (.913), whereas that for the FRB index of durable goods production and copper consumption in the brass mills is low (.479).

Supply shortages (including uncertainty as to supply) led to the temporary loss of some important brass markets in the 1950's. One of these was the automobile hub cap market, in which stainless steel made substantial inroads. When the copper supply improved and prices returned to more normal levels, brass got much of the market back. This was repeated in many other lines where brass is in competition with plastics and other products. On the other hand, military consumption in Korea and Viet Nam boosted brass demand much above the level that could be sustained for long. These wide variations around the trend line do not seem to form a pattern which calls for a departure from a straight-line regression correlation between copper consumption in the brass mills and the FRB index of industrial goods production.

Analysts in the industry have admitted that the brass mill pattern does not yield to statistical analysis, except perhaps through a highly disaggregated approach for which the figures are not available (for example, substitution of brass by plastics). Since copper use in the brass mills seems to return to the trend when supply is uninterrupted, we have projected on that basis.[2] The total projection is the sum of separate projections for the wire mills and for other uses (table 32).

Exports of copper were considered to be reexports; imports of blister in bond for refining and reexport were not included in consumption. The United States is a heavy net importer of refined copper, and exports are of negligible size and importance. Exports of copper scrap are important, primarily because the world refined copper price (London Metal Exchange) is often above the administered price set by United States refineries. When U.S. refinery supply is adequate, then scrap prices in the United States are low and attractive to foreign buyers. Copper scrap exports have often been limited by the U.S. Government to preserve domestic supplies. In any case, scrap exports were considered as reexports and not part of demand for United States copper (table 33).

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[2] That is, the wide variation and low coefficient of significance (R^2) were considered not to have invalidated the regression equation of copper consumption by the brass mills on the FRB index of durable goods production.

Lead

Lead is unusual among metals in that it has suffered heavy competitive inroads from other materials in a short period of time. In part, this was due to the scarcity of lead during the Korean War, which intensified efforts to bring in substitutes that had been under study for years. Several new developments that were inevitable in the long run converged in the 1950's. Titanium and, later, plastics captured the paint market in the post-World War II period. The development of catalytic cracking of gasoline temporarily reduced the use of tetraethyl lead. Because of improvements in the efficiency and useful life of storage batteries, use of lead in batteries did not increase as rapidly as the increase in the number of automobiles. Thus, in spite of low prices for lead, consumption did not pick up as one would have expected. High demand during the Korean and Viet Nam Wars created variations from the regression line, but the lack of correlation between lead consumption and the FRB index of durable goods production was due mainly to the fact that lead consumption, perversely, was going down in some years while the index was going up. In 1965 the consumption of lead (1.242 million short tons) was only a little above 1955 and 1956 (1.213 million and 1.210 million, respectively) and was almost the same as in 1950 (1.238 million).

The reasons for the commodity behavior of lead rest in the nature of lead supply. The metal is one of the less common materials in the earth's crust. Over the long run, economies in the use of lead must be developed or the supply will be very short. Yet when it does occur in nature, lead is found in rather rich deposits that are not difficult to mine and smelt. Thus, modest increases in price can quickly bring out a surplus. At other times, demand can quickly outrun existing supply. The situation would be chaotic if it were not for the existence of large supplies of secondary lead (chiefly storage batteries), which can be called on quickly.

The rate of growth indicated by a regression line of lead consumption on the FRB index of durable goods production was accepted more because it coincides with the logic of lead supply and demand rather than because of the degree of correlation (r=.509). The trend for lead was established using the years 1940-66, since there is evidence of a distinct change in relationship between the FRB index and lead consumption in that period compared with the pattern of the 1920's and 1930's.

Exports of lead metal are negligible, since the United States is a heavy importer.

Zinc

The demand for zinc was more stable in the 1950's than that for copper and lead. It was affected by erratic demand for brass, which was caused by copper fluctuations. Zinc was, and is, in direct competition with aluminum and plastics in diecastings, and it has been heavily substituted by plastics in paint. Yet it has not been totally displaced in any of these lines of use. Small price changes permit zinc to meet aluminum and plastics competition. Galvanizing, which is the second largest use, has held up rather steadily from year to year. Zinc in alloys (both in brass and for diecasting) fell off in the late 1950's. Diecasting recovered in 1962, but in brass, copper is the dominant ingredient by value, so that shortages and high prices of copper impinge on zinc demand.

The correlation of zinc with the FRB index of durable goods production was not high, but was acceptable (.808). It would undoubtedly have been higher if the demand by the brass mills had been steadier. Here, as in the case of lead, a distinct pattern emerged from the 1940-65 period, and we used the longer series for our equation.

Zinc is similar to lead in that it is rather easy to mine, smelt, and refine. It is not one of the more abundant materials, such as aluminum or magnesium. Over the longer term, the consumption of zinc, while it may increase faster than that for lead, must be restricted or supply will be tight and it will price itself out of the market. Secondary zinc is less of a factor than is secondary lead, since almost all galvanizing zinc is lost as well as other zinc used for protective purposes.

Exports of zinc are negiglible, since the United States is a heavy importer.

Projections of Minor Metals and Additives

Magnesium

Magnesium is a metal that has come into prominence since World War II. In 1944 consumption had reached 132,000 short tons, but by 1948, the industry was practically starting over at 17,500 short tons. Consumption grew rapidly, with short recessions in 1954, 1958, and 1960 which coincided with industrial recessions. The correlation with the FRB index of durable goods production was very close from 1948 to 1965, with a coefficient of .983.

The advantages of magnesium are due to its strength-to-weight ratio. Technical difficulties in fabrication and use held back its civilian applications. These difficulties were less important in military uses where cost was less of a factor; hence, the high usage in wartime. As the techniques of using magnesium developed, consumption in the United States plus exports increased several-fold between 1948 and 1965 -- from 17,500 to 101,000 short tons. Compared with the potential uses of magnesium, this is still a small tonnage. There are still engineering difficulties with magnesium, but as they are overcome there is little doubt that use of magnesium will increase substantially. One especially important use is in the refining of titanium, the use of which is bound to increase rapidly in industry.

Projections using the FRB index of durable goods as the independent variable indicate a demand of 246,000 short tons as a medium figure for 1980. By 2000 this could rise to 522,600 short tons (table 32). These figures do not include exports, which have been an important part of U.S. demand.

Exports have increased more rapidly than domestic consumption, from 444 short tons in 1948 to 17,800 tons in 1965. However, other countries with the industrial capability for producing and using magnesium have been delayed in getting into production. They have generally been induced to design into magnesium, because of its availability, before they were ready to produce their own metal. As is evident, there is still excess producing capacity in the United States.

The rate of increase of U.S. exports may be expected to slow down, whereas total exports may well continue to increase, as they have in aluminum. Projections for magnesium exports could range from a low of 25,000 to a high of 142,000 short tons for 1980. The range would be correspondingly wider for the year 2000. The most difficult factor to assess is the future progress of foreign industry, which may depend to a considerable degree on national policies. There is no demonstrable medium probability, but it is reasonable to expect that a medium figure for 1980 might be 50,000 short tons, and for 2000, about 100,000 short tons (table 33).

Mercury

The erratic nature of Mercury consumption has been primarily due to supply problems. The wide fluctuations in price were discouraging to consumption in lines in which mercury was a major element in the final product and consumption could be postponed. For example, the widest variation is found in agricultural uses and in those classified as "other," whereas in industrial uses, such as electrical apparatus and in chemical processes, consumption has grown steadily along with the indexes of industrial production. In at least one sector of demand, industrial and control instruments, the trend has been downward, from 6.525 million flasks in 1960 to 3.106 million in 1965. As a result of these diverse movements in consumption, the coefficient of correlation of mercury consumption with the FRB index of industrial production is on the margin of acceptability (.808).

The variations in supply are due to the structure of the industry. There is a wide gap in costs between the Spanish producer (Almaden), the lowest cost producer, and the Italian producers, who are next lowest in cost, and all other mercury suppliers (including those in the United States). Repeatedly the low-cost producers have restricted supply to raise prices, but they carried this policy so far that marginal producers began to increase production. A surplus resulted, with heavy price cuts to drive high cost producers out. These practices also led to inventory speculation which, at least at times, reinforced the extremes.

If supply had been more regular, it is probable that consumption of mercury would have reached higher levels than it has. On the assumption that the troubles of the mercury producers will not improve in the future, and that shortages and surpluses will continue to plague the industry, consumption was projected using the regression equation of mercury consumption, 1949-65, on the FRB index of industrial production. This resulted in an estimated consumption of 152,800 flasks (76 lbs.) as a medium figure for 1980, and 288,200 flasks for 2000, compared with 76,500 in 1965 (table 32). This is not to predict that so much mercury will be produced, but that if it were available, it would probably be consumed.

Exports of mercury are to be treated as reexports, since the United States imports two-thirds or more of its supply. Exports are nominal in most years, amounting to less than 1 percent of the U.S. supply. In years when world prices were higher than U.S. prices, for example in 1965 when stockpile mercury was released, exports increased to 7,500 flasks. These were not representative of normal exports of the United States.

Manganese Ore

Manganese consumption is closely associated with steel output. A 2-year moving average of manganese imports for consumption and shipment to mills by domestic mines was correlated with a 2-year moving average of crude iron and steel production. This produced a coefficient of correlation of .97.

There is no substitute on the horizon for manganese in steel production. The projected quantities of manganese indicate that recourse to lower grade ores, including those of the United States, is a distinct possibility, as well as the recycling of steel mill slags. The latter has been studied frequently, but up to now has been found uneconomic.

Exports are almost nonexistent and it is not likely that this situation will change before 2000.

Nickel

The United States imports all but a small quantity of its nickel supply. The bulk of it comes from Canada, where the International Nickel Company continues to hold its share of the market at more than 60 percent [3]. A small amount, about 12,500 short tons, was produced in the United States in

1965, compared with the consumption of 172,000 short tons in that year.

Nickel is used in a wide variety of products, but the most important is stainless steel, which accounts for about 33 percent of United States nickel consumption. Other uses are for plating (16 percent), high nickel alloys (14 percent), alloy steel for construction (12 percent), and iron and steel castings (11 percent). These uses are highly correlated with the FRB index of durable goods production, yielding a coefficient of .918. This correlation would undoubtedly be higher if it were not for occasional shortages of nickel. These shortages are met in several ways -- lowering the nickel content in alloys and plating, recourse to chrome stainless steel in noncritical uses, and heat treating or substitution of manganese, vanadium, and other ferro-alloys at some sacrifice in cost and performance. Thus, the use of nickel may lag behind the durable goods index. Nickel also has military uses which stimulate demand in time of emergency to levels higher than would be measured by the index. Thus, the estimating equation using the durable goods index as an independent variable is considered to be very good for purposes of projection.

The medium estimate for 1980 consumption of nickel is 327,600 short tons and for 2000, 651,700 short tons (table 32). These figures appear large at first glance, but reflection on future demand for jets, rockets, space machinery, and the myriad of other uses for this versatile material shows that the estimates may even be conservative.

Industry and trade sources apparently agree that free world demand for nickel will increase by about 6 to 7 percent per year [3, p.3]. Our estimating equation has a slope of 6.9 percent for the United States, which is consistent with industry expectations.

Exports of nickel are in the form of scrap, which should be considered as a reexport. Nickel in scrap is usually priced well below primary nickel, which makes it attractive to export. If it were not so priced, domestic consumers would consider primary nickel to be in short supply and begin to bid up the price of free nickel (that is, not distributed by International Nickel Company and other major suppliers at administered prices). This was the condition in 1967 -- nickel scrap exports were high, with consequent high prices for free nickel. However, such exports should not be thought of as demand for U.S. nickel.

Molybdenum

Molybdenum and tungsten are directly substitutable for each other in some important steel alloys. Which will be used depends upon their relative prices. The changeovers take time and are costly, however, and will be made only when the price differentials promise to persist for some months or years. Molybdenum is relatively stable in production and price, because the major world supply comes from the United States. There are only a few producers, and the Climax mine is still the largest. Tungsten, on the other hand, is widely produced. The largest producer is China. Erratic marketing has caused shortages and surpluses of tungsten. Thus, alloy steel producers have designed into molybdenum, and have resorted to tungsten when they had to, or when tungsten was very cheap. Molybdenum consumption in 1965 in the United States was 72.7 million pounds, compared with 13.6 million pounds for tungsten.

Molybdenum production has been occasionally upset by strikes, so that consumption has been irregular (though less so than tungsten used in steel). Molybdenum consumption alone does not correlate very well with the indexes we are using. When the consumption of tungsten in steel is added to molybdenum consumption, the coefficient of correlation is .90. Molybdenum has made up 95 percent or more of the total molybdenum-plus-tungsten used in steel in recent years, so the projections were labeled molybdenum demand, although it should be noted that moderate amounts of tungsten are included.

Exports of molybdenum are an important part of demand for U.S. production. They have comprised an increasing proportion of total molybdenum shipments, averaging 39 percent for the period 1961-65. This proportion of demand could easily continue in the future, depending on the reliability of U.S. supply. Exports are projected at 40 percent of total U.S. shipments. European consumers in particular favor molybdenum over tungsten, and have designed their products and processes to use it. It should be noted that China could alter future patterns by selling tungsten cheaply. It should also be noted that the medium estimates of 125.3 million pounds for 1980 and 249.5 million pounds for 2000 include exports. United States domestic shipments would be 60 percent of the total.

Tungsten

Tungsten has had an erratic supply and price history because the world's greatest and cheapest supplier is China. While tungsten consumption has more than doubled since 1948, the quantity used in steel alloys has not changed appreciably. About 25 percent of U.S. consumption is largely, though not wholly, interchangeable with molybdenum in steel. The other uses, such as cemented carbides, have increased steadily. Consumption for uses other than steel-making was correlated with the FRB index of industrial production, yielding a coefficient of correlation of .895. Except for erratic interruptions in supply, this figure would have been substantially higher. Total demand for tungsten would include some allowance for use in steel, which has been about 25 percent of tungsten consumption, but this proportion should decrease slowly, to about 20 percent by 1980 and 15 percent by 2000. These estimates of the balance between molybdenum and tungsten could be upset by changes in world supply of either metal.

Exports of tungsten would be highly unusual since the protected domestic industry has a price higher than the world market level.

Vanadium

Vanadium demand is closely associated with the FRB index of industrial production. The coefficient of correlation is .967. Eighty percent of Vanadium goes into iron and steel production, but other uses are developing. Vanadium has been in good supply because it is a by-product of uranium refining. This has encouraged the design of vanadium-bearing products and has stimulated a high rate of growth in its use. Future requirements for both 1985 and 2000 are staggering compared with present levels (table 32). However, this situation is true for a number of metals, and if presently indicated rates of growth continue, it will be necessary to think in new orders of magnitude for those materials.

The United States imports vanadium and is expected to continue to do so.

Diatomite

Diatomaceous earth, or diatomite, is a chalky deposit formed of fossilized plankton, or diatoms, which has several useful properties. It has good insulating qualities and in the form of bricks, sawn blanks, or powder will withstand high heat. It is widely used to filter water and other materials, and is also used in paints. Although it is not a popularly known mineral, it has been used in industry for years. Consumption has been growing steadily in the United States and abroad since World War II. In the United States it is chiefly found in California, Nevada, Oregon, Washington and Arizona.

The consumption of diatomite has been closely correlated with the FRB index of industrial production. The coefficient of correlation between the index and sales of diatomite between 1948 and 1965 is .985. Consumption data is in the form of 3-year averages of sales to avoid disclosure of confidential statistics. This probably contributes to the high degree of correlation. Projections based on the foregoing relationship yield a medium estimate of U.S. consumption plus exports of 1.48 million short tons in 1980 and 3.02 million in 2000. Exports have been running about 20 percent of sales and we see no reason for that to change. The average value of exports indicates that the bulk of the material has been processed in the United States. For that reason, recorded exports are included as U.S. consumption.

An independent estimate placed projections for 1985 and 2000 at 800,000 and 1.4 million short tons, respectively.3/ These are far short of our projections. The independent estimate is essentially a time-trend projection of U.S. sales less exports. As noted above, we included exports and, also, projected growth of the industrial production index at a higher rate than that of the 1950's. Diatomite consumption grew rapidly and steadily while the economy backed and filled through several recessions. The rate of increase in consumption per point of index was high, and now that GNP is increasing more rapidly, future growth in diatomite should be at a faster rate than in the past. Diatomite sales increased by 240 percent between 1949 and 1964, while the index of production rose 190 percent. If the index rises 212 percent in the next 15 years, the demand for diatomite will rise 267 percent above 1964, which would be near our figure. It is expected that the demand for diatomite will approach the quantities projected if presently foreseen conditions hold, but it cannot be predicted that reserves and costs will permit that amount to be produced and sold.

Sand and Gravel

Consumption of sand and gravel have been combined with crushed stone consumption to arrive at a figure for consumption of aggregates. The very great expansion of concrete construction, which accounts for more than half the usage of these materials, has stimulated steady growth of the industry. The production of heavy aggregates has more than tripled since 1948.

Crushed stone constituted a larger percentage of the total in 1965 (46 percent) than it did in 1948 (41 percent). As the better deposits of gravel are exhausted, this ratio can be expected to increase until, in 1980, more crushed son stone than gravel will be used. This trend is not as great in the West, where only about 50 million short tons of crushed stone were used for concrete and roadstone in 1965, out of a total of 503 million tons for the Nation. Total use of crushed stone was 777.7 million tons in 1965, but distribution by region is not available. On the other hand, the West used 274 million tons of sand and gravel in 1965 out of a national total consumption of 908 million tons. When crushed stone and sand and gravel are added together and distributed by region, the totals correspond reasonably with the regional shares of construction (table 34).

There is apparently a substantial movement of aggregates between regions in spite of their bulk, low value, and consequent high transport costs. From the sample available from the 1963 *Census of Mineral Industries* [6], the Northeast Region produced only about 15 percent of the aggregates, but accounted for 24 percent of construction. The North Central Region accounted for 26 percent of the total construction, but produced more than 36 percent of the aggregates. The West apparently produced about 25 percent of the aggregates and was the site of 24 percent of the construction. That would be expected in view of the shipping distances from the West to consuming centers in other regions.

3/ An informal communication with the U.S. Bureau of Mines, used here to show the range of estimates that are possible with different techniques and to give perspective to our projections.

Table 34. Consumption of Sand, Gravel, and Crushed Stone, by Region, 1965 and Projected 1980 and 2000

(in millions short tons)

Region	1965	1980			2000		
	(actual)	Low	Medium	High	Low	Medium	High
United States a/..	1,685.7	4,106.4	4,561.6	4,721.3	9,338.5	11,221.8	12,508.8
Northeast	423.1	956.8	1,062.9	1,100.1	2,007.8	2,412.7	2,689.4
North Central...	409.6	1,047.1	1,163.2	1,203.9	2,493.4	2,996.2	3,339.8
South	456.8	1,096.4	1,217.9	1,260.6	2,474.7	2,973.8	3,314.8
West:							
Montana	10.1	24.6	27.4	28.3	56.0	67.3	75.1
Idaho	13.5	20.5	22.8	23.6	37.3	44.9	50.0
Wyoming	1.7	12.3	13.7	14.2	28.0	33.7	37.5
Colorado	25.3	82.1	91.2	94.4	224.1	26.9	30.0
New Mexico ...	8.4	24.6	27.4	28.3	65.4	78.6	87.6
Arizona	23.6	82.1	91.2	94.4	233.5	280.5	312.7
Utah	15.2	32.9	36.5	37.8	65.4	78.6	87.6
Nevada	15.2	20.5	22.8	23.6	37.4	44.9	50.0
Washington ...	30.3	65.7	73.0	75.5	130.7	157.1	175.1
Oregon	18.5	45.2	50.2	51.9	102.7	123.4	137.6
California ...	230.9	554.4	615.8	637.4	1,242.0	1,492.5	1,663.7

a/ Includes Alaska and Hawaii.

Source: 1965 data from [7].

The aggregates were projected using an estimating equation from the regression of consumption of aggregates on on the FRB index of construction materials. This index in turn was projected by correlation with GNP. The resulting national totals were distributed regionally on the basis of projections of construction by region by value for 1980 and 2000. The construction projections were based on estimates by the National Planning Association for 1975 extrapolated to 1980 and 2000 by trend, but with a slight adjustment of the extremes toward the average in the rates of growth.

CHAPTER V

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CHAPTER VI

MINERAL FUELS AND ELECTRICITY

In this chapter, projections of the residential, commercial, industrial and transportation consumption of mineral fuel and electricity are presented, as well as fuel consumption for electricity generation in 1980 and 2000.

The projections are based on the methods and projections of a 1963 study by Resources for the Future, Inc. (RFF) [16].

Essentially, the RFF approach was to project several independent variables (e.g., population, tons of steel) which are determinants of energy consumption for each energy-consuming sector (e.g., residential, industrial), and to project unit energy consumption both for fuels (in B.t.u.'s) and electricity in units of fuels or electricity required per unit of output. Projections of individual fuels were obtained by allocating shares of total fuel requirements on a percentage basis to gas, oil, and coal. The RFF projections and their underlying assumptions have been examined and adjusted in the light of developments since 1960.

Projections of residential consumption of energy were related to the number of households in the United States in 1980 and 2000. Projections were made of the number of households with spaceheating, air conditioning, lighting, and six major appliances; the proportion of appliances using electricity, gas, coal, or oil; and the annual energy requirements of each appliance.

Commercial consumption of energy fuels historically has shown a remarkably constant relationship with residential consumption, and is projected on the basis of the expected future relationship to residential requirements.

Projections of industrial consumption were made for each of the following industrial uses: steel and nonferrous metals production, "all other" manufacturing, petroleum refining, mining, and the Atomic Energy Commission (AEC).[1]

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[1] Electric power consumed by AEC installations.

Independent variables were tonnages of production for steel and nonferrous metals and the Federal Reserve Board indexes of industrial production for "all other" manufacturing and mining. Projections of these variables were then related to estimates of fuels and electricity consumption per ton of production or per point of the industrial production index. The projections of unit energy consumption allowed for advances in technology and efficiency. Projections of energy consumption by petroleum refining were related to total requirements for petroleum.

The independent variables used to determine transportation requirements were the stocks and annual mileages of cars, trucks, and buses. Truck and car stocks were projected on the basis of their relationships to Gross National Product (GNP) and population. Total mileages were then multiplied by estimates of fuel consumption per vehicle mile.

Electricity generation in the United States was obtained by totaling the projected requirements for each end use and adding the estimated transmission losses.

The projection for hydro generation in 1980 was based on projections by the Federal Power Commission [12]. These projections have been updated and modified to include changes in plans that have occurred since 1964. For 2000, an estimate was made of the remaining unused hydro sites that would be developed between 1980 and 2000.

Nuclear generation estimates were based on the most recent projections by the Atomic Energy Commission. Projections of the quantities of coal, oil or gas to be used for electricity generation were based on the total amounts of electricity which will be generated from conventional fuels (i.e., total generation less hydro and nuclear generation) and from estimates of fuel required per kilowatt hour of generation.

National Consumption of Mineral Fuels

The medium projection of the consumption of conventional fuels (coal, oil, ang gas) in the United States indicates an increase from 52 quadrillion B.t.u.'s in 1965 to 79 quadrillion in 1980, and to 126 quadrillion in 2000. Coal consumption is projected to increase by 118 percent from 1965 to 2000, oil consumption by 146 percent, and gas consumption by 158 percent.

Table 35. U.S. Consumption of Coal, Oil and Gas, 1965 and Projected 1980 and 2000

(Quadrillion B.t.u.'s)

Fuel	1965 (actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Coal...	14	19	20	21	27	30	34
Oil....	21	~~28~~ 27	31	~~36~~ 35	44	53	68
Gas....	17	26	28	29	38	44	49
Total.	52	~~73~~ 72	79	85 ~~86~~	110	127	151

Source: 1965 data calculated and summarized from 17 sources. See Appendix tables.

The medium projections of the annual consumption of uranium (U_3O_8), at present only a few thousand tons, provide for an increase to about 40,000 tons by 1980 and to 75,000 tons by 2000.

For electric power generation, which will require both conventional fuels and uranium, the medium projections indicate an increase from 1.2 trillion kilowatt hours in 1965 to 2.8 trillion in 1980, and 6.1 trillion in 2000.

The projections of conventional fuels are expressed as requirements for coal, oil, or gas. Crude petroleum may not be the only source of oil in 2000; oil from coal, oil shale, and tar sands are all economic possibilities before the end of the century. Similarly, gas from coal could become a substitute for natural gas. No projections have been made, however, of the possible consumption of coal that might result from use for conversion to oil or gas.

Table 36. U.S. Consumption of Energy, by Use, 1965 and Projected 1980 and 2000

Item	1965 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Conventional fuels[a/]	------- Quadrillion B.t.u.'s -----------						
Residential and commercial.......	9	12	13	13	12	13	13
Industrial........	12	19	21	22	33	39	44
Electric generation............	11	14	16	16 ~~20~~	20	22	24
Transportation....	10	15	16	18	26	31	36
Other.............	10	11	13	15	17	22	29
Total..........	52	73 72	79	~~86~~ 85	108	~~125~~ 127	146
Other Sources of Energy[b/]							
Hydroelectric power............	2	3	3	3	3	3	3
Nuclear fuel......	neg.	9	9	9	22	25	27
Electricity[c/]	--------- Trillion kw.-hrs. -------------						
Residential and commercial.......	0.5	1.3	1.4	1.4	2.8	2.9	3.1
Industrial........	0.5	0.9	1.0	1.1	1.8	2.1	2.4
Other.............	0.2	0.4	0.4	0.4	0.9	1.0	1.1
Total..........	1.2	2.6	2.8	2.9	5.5	6.1	6.7

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a/ Oil, coal, and gas.

b/ Generation of electric power from hydro and nuclear sources, converted at the average heat rate for conventional fuels.

c/ Represents total generation of electricity from all sources.

Source: 1965 data calculated and summarized from 17 sources. See Appendix tables.

The greatest increase in the consumption of conventional fuels will occur in industrial markets. The medium projections indicate an increase of 225 percent in the use of such fuels between 1965 and 2000. Transportation requirements will treble during the same period, but residential and commercial uses of these fuels are expected to increase by about 40 percent. Consumption of conventional fuels for electricity generation is estimated to double.

All end uses of electricity will increase rapidly between 1965 and 2000. Industrial demand is expected to quadruple, and residential and commercial consumption is expected to increase fivefold.

Gas

The medium projection for the consumption of gas in the United States provides for an increase from 16.3 trillion cubic feet in 1965 to 27.0 trillion in 1980, and to 42.2 trillion in 2000 (table 37).

Two-thirds of the incremental demand will come from industry, which is estimated to increase its share of total gas consumption from one-fourth to one-half by 2000. Residential and commercial consumption will increase about 56 percent during this period, and consumption for electric power generation 65 percent.

Overall, gas is expected to increase its share of the total market for conventional fuels from 33 percent in 1965 to 35 percent in 2000. As indicated, much of the growth will be concentrated in the industrial market, where gas has considerable advantages as a fuel over either coal or oil. Convenience of handling, cleanliness, lack of storage problems, and better heat control outweigh the higher cost of gas in many cases. The use of gas for primary metals production and for petroleum refining is expected to quadruple by 2000, and "all other" manufacturing consumption, which accounts for over half the industrial market, is projected to increase from 3.0 trillion cubic feet in 1965 to 15.3 trillion in 2000.

In the more cost-sensitive large-volume markets for fuels, notably the electric utilities, gas is consumed primarily in the producing States. Present regulatory policies

Table 37. U.S. Consumption of Natural Gas, by Use, 1965 and Projected 1980 and 2000

(in billion cubic feet)

Use	1965 (actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Residential..............	3,867	5,487	5,584	5,680	4,954	5,247	5,620
Commercial[a/]............	1,838	2,992	3,044	3,098	3,431	3,635	3,893
Industrial...............	4,530	8,677	9,428	9,868	17,259	20,272	22,925
Electric generation......	2,569	3,227	3,534	3,729	3,764	4,229	4,678
Transportation[b/].........	309	497	524	549	716	807	901
Other[c/].................	3,211	4,593	4,906	5,241	6,744	7,973	9,399
Total..................	16,324[d/]	25,473	27,020	28,165	36,868	42,163	47,416

[a/] Includes other nonindustrial uses.
[b/] Natural gasoline originating in natural gas processing.
[c/] Includes carbon black, pipeline fuel, transmission losses, field use, gas vented and wasted, and natural gas liquids originating in natural gas processing (excluding natural gasoline). Exports of gas were negligible in 1965 and are expected to be negligible in 1980 and 2000.
[d/] This compares with the Bureau of Mines [24] figure of 16,359 billion cubic feet for gross withdrawals less quantities used for repressuring.

Source: 1965 data calculated and summarized from 13 sources. See Appendix tables.

do not permit firm sales of large amounts of gas for boiler fuel outside the producing States. This situation is not expected to change significantly in the future, and the share of the electric utility market for conventional fuels which is allocated to gas is projected to decline from 26 percent in 1965 to 20 percent in 2000.

For the small-volume residential and commercial markets, where convenience rather than cost usually determines the choice of a fuel, gas has considerable advantages over both coal and oil. Increases in residential and commercial consumption, however, are not expected to be as rapid as industrial consumption because of inroads into residential and commercial gas markets by electricity. In 1965, less than 2 percent of American homes used electricity for spaceheating; spaceheat accounted for about three-fourths of household energy consumption. By 1980, however, 18 percent of all homes are expected to use electric spaceheat and, by 2000, 40 percent of all homes will rely on electricity.

The consumption of gas for purposes other than residential and industrial includes transmission losses, field use, and gas for natural gasoline and other natural gas liquids.

The consumption of natural gas liquids, most of which originate in natural gas processing and appear, therefore, as a demand for gas, is expected to quadruple by 2000. The requirements for chemical industry feedstock and natural gasoline (a function of gas production) will account for most of this growth (table 38).

Exports of gas or natural gas liquids are expected to be negligible in 1980 and 2000.[2/] At the present time almost all gas used is natural gas. In recent years, proved reserves of natural gas have been about 20 times current production, sufficient only to about 1985. Whether or not gas from other sources will become available at competitive prices before 2000 is open to question. The most likely source at the present time appears to be from the gasification of coal, and a

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[2/] A plant is being built in Alaska to produce liquified natural gas. An estimated 63 billion cubic feet will be processed each year, some of which will be exported to Japan.

Table 38. U.S. Consumption of Natural Gas Liquids by Use, 1965 and Projected 1980 and 2000

(in million barrels)

Use	1965 (actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Residential........	81	101	103	106	59	63	66
Commercial.........	30	37	37	37	44	44	44
Industrial.........	163	297	397	539	742	1,336	1,945
Transportation[a] ...	246	399	419	438	599	664	734
Other[b]	14	19	20	21	18	26	44
Total..............	534	853	976	1,141	1,462	2,133	2,833

[a] Motor fuel and natural gasoline.
[b] Agriculture.

Source: 1965 data calculated and summarized from 7 sources. See Appendix tables.

great deal of research is being directed toward this process. No estimate of the possible consumption of gas produced from coal has been made in this study.

Oil

The medium projections of requirements for oil show an increase from 3.7 billion barrels in 1965 to 5.3 billion in 1980, and to 9.1 billion in 2000 (table 39).

In 1965, 49 percent of all oil consumption was for transportation; by 2000, transportation's share of total oil consumption is projected to increase to 60 percent and to account for over two-thirds of incremental demand for oil.

Increased consumption of oil will also occur in industry and among various miscellaneous uses, such as defense. Residential use of oil by 2000 is estimated to be half of the consumption in 1965, and consumption by electric utilities will also decline.

Apart from transportation, where oil supplies about 90 percent of the energy requirements and is projected to continue to do so, the requirements for oil relative to other conventional fuels will decline. In the industrial markets, where oil is expected to retain its competitive position most effectively, a decline from 21 percent in 1965 to 19 percent in 2000 is projected.

Disadvantages of oil compared with gas and electricity are most pronounced in the small-volume residential and commercial markets, where it is used primarily for spaceheating. For many people, lower operating costs for oil do not offset the greater convenience and lower installation costs of gas or electricity. As a result, the downward trend in oil's share of these two markets is expected to continue. By 2000, oil is estimated to meet only 12 percent of the residential demand for fuels, compared with 30 percent in 1965.

The use of residual fuel oil for electric power generation is also projected to decline. Not only is less residual

Table 39. U.S. Consumption of Oil, by Use, 1965 and Projected 1980 and 2000

(in million barrels)

Use	1965 (actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Residential........	462	356	362	368	240	254	273
Commercial.........	156	190	174	161	288	289	299
Industrial.........	394	580	633	682	980	1,151	1,355
Electric generation............	128	114	125	133	98	110	121
Transportation[a/] ...	1,865	2,748	2,969	3,412	4,797	5,473	6,787
Other[b/]	772	805	1,061	1,366	1,202	1,849	2,782
Total..............	3,777	4,793	5,324	6,122	7,605	9,126	11,617

[a/] Natural gasoline originating in gas processing subtracted from total transportation demand.

[b/] Defense, agriculture, asphalt and road oil, liquid refinery gas, miscellaneous uses, and exports.

Source: 1965 data calculated and summarized from 13 sources. See Appendix tables.

oil available from domestic production because of improved refining techniques, but import quotas on residual fuel oil limit its availability. Policies relating to the latter would have to change before there could be a substantial increase in the amount of residual oil used.

Exports of petroleum products are expected to be negligible in 1980 and 2000. The projections have been made for oil, most of which will probably be supplied by petroleum products. Extensive deposits of oil shale in the United States and tar sands in Canada, together with oil from coal, could, however, provide alternative sources. Production has already begun from the tar sands and pilot plants are in operation to develop the other sources.

Coal

The medium projections of the consumption of coal in the United States call for consumption to increase from 524 million tons in 1965 to 773 million in 1980, and to 1,140 million in 2000 (table 40).

Nearly three-fifths of the incremental consumption of coal from 1965 to 2000 will be for electricity generation. More than 600 million tons is estimated to be consumed in this market by 2000, over twice the amount used in 1965.

Apart from exports, which are expected to increase from 50 million tons in 1965 to 100 million in 2000, the rest of the incremental demand for coal will occur primarily in industrial uses, expanding from 171 to 395 million tons during the period. Three-fourths of the incremental industrial consumption will be metallurgical coal. Direct consumption of coal for residential and commercial uses by 2000 will probably be negligible.

Overall, coal is not expected to lose much of its share of the total market for conventional fuels. This is due primarily to the projected improvement in its competitive position in the market for electricity generation, where its share of the conventional fuels will increase from 66 percent in 1965 to 77 percent in 2000. The long-distance transmission of power, large minemouth generating plants, and unit trains have improved the competitive position of coal in recent years, and are expected to continue to do so.

Table 40. U.S. Consumption of Coal, by Use, 1965 and Projected 1980 and 2000

(in million tons)

Use	1965 (actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Residential........	14	6	6	6	--	--	--
Commercial.........	15	4	9	11	4	8	11
Industrial.........	171	248	263	271	352	396	458
Electric generation.............	273	380	425	439	575	636	714
Exports...........	51[a]	70	70	70	100	100	100
Total...........	524[b]	708	773	797	1,031	1,140	1,283

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a/ Includes railroads for 1965. No railroad consumption is projected after 1965, when it was 1 million tons.
b/ Compares with an estimated production of 512 million tons in 1965 [24].

Source: 1965 data calculated and summarized from 13 sources. See Appendix tables.

Even though coal will also retain its importance as a fuel in primary metals production, its share of the market for other types of manufacturing will decline. Many of these industries are small-volume consumers of fuel and, as in the case of both the residential and commercial consumers, coal has serious disadvantages in these industries.

The possibility of obtaining both gas and oil from coal before the end of the century has been discussed above. If this should become a reality, it would obviously create additional requirements for coal. Given the present state of technology, however, there is no real basis for estimating the magnitude of this market by 2000.

Air pollution regulations are not expected to have any long-run impact on coal consumption, since the development of technology for the effective removal of pollutants appears almost certain.

Uranium (U_3O_8)

The medium projections of uranium requirements of the electric utility industry are 42,000 tons of uranium in 1980 and 75,000 tons in 2000. The 1980 projection is essentially that of the Atomic Energy Commission (AEC), and is related to a projection of 145,000 mw of nuclear generating capacity by 1980. Although the Atomic Energy Commission suggested a possible range in civilian nuclear capacity of 120,000 to 170,000 mw in 1980 [5], 145,000 mw was considered the most likely level of capacity and was used for AEC projections of uranium requirements. All projections of generation from nuclear capacity presented in this report are based on the AEC projection of 145,000 mw. The low projection of uranium for 1980 assumes that plutonium recycling will be introduced around 1975, and the high projection assumes that plutonium recycling will not be introduced until after 1980. Production of uranium in 1965 was about 10,500 tons.

The increase in the consumption of uranium results almost entirely from the growth in nuclear generating capacity. Demand from the Government, for nuclear weapons, hitherto the major consumer, has leveled to about 8,000 tons per year and will under present plans terminate at the end of 1970.

The AEC has not made estimates of uranium requirements after 1980. It is projected in this report, however, that about 3 trillion kilowatt hours will be supplied from nuclear power plants in 2000, requiring approximately 500,000 mw of nuclear capacity. The amount of uranium used to generate this power will depend primarily on the timing of the introduction of breeder reactors.

In projecting low requirements for uranium in 2000 it was assumed that breeder reactors will be introduced in 1985[3] and that all additional capacity after that date will be from breeder reactors. The medium projection assumed that breeders would be used only after 1990 and, for the high projection, it was assumed that no breeder reactors would be introduced before 2000. With the introduction of breeder reactors, the demand for new uranium will gradually diminish since the breeders reprocess spent fuel so that it can be used again. The resulting projections of U.S. consumption of uranium are shown in the tabulation below:

	Thousand tons
1965 (actual)....	10.5
1980:	
Low.............	40
Medium..........	42
High............	45
2000:	
Low.............	55
Medium..........	75
High............	100

Exports of uranium are expected to be negligible.

Electricity[4]

The medium projections of the generation of electric power indicate an increase from 1.2 trillion kilowatt hours in 1965 to 2.8 trillion in 1980, and to 6.1 trillion in 2000 (table 41).

Residential consumption of electricity is expected to increase by about 350 percent and commercial consumption by about 550 percent between 1965 and 2000. In addition to an increase in the number of consumers, rapid growth of consumption per consumer is also projected. This is primarily due to an increase in the number of electric appliances per consumer and to the substitution of electricity for the direct use of fuels, particularly for spaceheating.

Consumption of electricity by industry is projected to increase from 457 to 2,132 billion kilowatt hours between 1965 and 2000. Almost 80 percent of the increase is accounted for by manufacturing (excluding primary metals and petroleum refining). Consumption of electricity for nonferrous metals production is projected to treble, from 58 to 181 billion kilowatt hours, and consumption for the production of steel (including electric furnace steel) will increase from 50 to 230 billion kilowatt hours between 1965 and 2000.

The rapid growth in the industrial consumption of electricity is due to increasing output, particularly in large power-consuming industries; to the substitution of electricity for the direct use of fuel; and to more power-intensive processing in some industries.

In 1965, approximately 17 percent of the total electricity generated was provided by hydro plants; by 1980, hydro's share of the total will have been reduced to 11 percent, and in 2000, to about 5 percent (table 42).

One of the most significant recent developments in the power industry has been the rapid acceptance of nuclear power plants. Although generation from nuclear plants contributed less than one-half percent of the total generation in 1965, since 1963 over 58,000 mw of capacity has been ordered, mostly for installation by the early 1970's. Based on the 145,000-MW AEC projection, an additional 85,000 MW will go into operation between about 1973 and 1980 -- perhaps 12,000 to 14,000 MW per year. Since over 16,000 MW has already been scheduled for 1972 and for 1973, the AEC projection does not indicate any acceleration in the rate at which nuclear plants will be added. Also based on AEC projections,

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[3] There will be a few experimental breeder reactors in operation before 1985.
[4] Thermal electricity generation has been included in the appropriate section of the fuel required to generate it.

Table 41. U.S. Consumption of Electricity, by Use, 1965 and Projected 1980 and 2000

(in billion kilowatt hours)

Use	1965 (actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Residential........	288	670	681	692	1,204	1,273	1,359
Commercial[a/].......	246	666	680	686	1,556	1,643	1,763
Industrial.........	457	898	991	1,050	1,769	2,132	2,429
Other[b/]...........	166	409	428	442	934	1,039	1,137
Total...........	1,157	2,643	2,780	2,870	5,463	6,087	6,688

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a/ Includes other nonindustrial.
b/ Losses and miscellaneous uses.

Source: 1965 data calculated and summarized from 13 sources. See Appendix tables.

Table 42. Generation of Electricity, by Source, 1965 and Projected 1980 and 2000

(in trillion kilowatt hours)

Source	1965 (actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Hydro...........	0.20	0.30	0.30	0.30	0.34	0.34	0.34
Nuclear.........	a/	0.89	0.89	0.89	2.73	3.06	3.38
Conventional fuels..........	0.96	1.44	1.58	1.67	2.39	2.68	2.97
Coal..........	0.64	1.03	1.12	1.19	1.84	2.07	2.28
Gas...........	0.25	0.35	0.38	0.40	0.48	0.54	0.59
Oil...........	0.07	0.07	0.08	0.08	0.07	0.08	0.09
Total.........	1.16	2.64	2.78	2.87	5.46	6.09	6.69

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a/ Negligible.

Source: 1965 data from [7, 10, 16].

projections ranging from 450,000 MW to 550,000 MW were made for 2000.

If the projected amount of nuclear capacity operates at about 70-percent load factor, approximately one-third of the generation requirements will be supplied by nuclear power in 1980 and one-half in 2000. The remainder of the power requirements will be generated by coal, oil, and gas, unless electricity from fuel cells, magneto-hydrodynamics (MHD), or some other new technology becomes economical. There is no basis at the present time for making estimates of the generation from such sources, since they are still in experimental phases of development.

Regional Projections of Electric Power Generation

Projections of regional electricity generation requirements are based on population projections and estimates of the per capita consumption of power in 1980 and 2000. It was assumed that the disparities in per capita consumption of electricity between the regions will be reduced between 1965 and 2000.

Historically, per capita consumption of power in a number of States, notably in the Pacific Northwest, has been much higher than the national average. This has been primarily due to the availability of inexpensive hydroelectric power, which both attracted large power-consuming industries and encouraged the use of electric power rather than conventional fuels for many residential and commerical energy requirements. Future per capita growth in these States is projected to be much slower in the future than in the past. Additional hydro sites are limited and large power-consuming industries are tending not to move to these States unless there are other locational advantages.

By contrast, per capita consumption in the Northeast, which has been below the national average in the past, is expected to grow more rapidly in the future. Historically, electricity has not been used extensively for spaceheat in the Northeast and industries in the Northeast have been on the whole, small consumers of power. However, pollution problems, the greater convenience of electricity, and a continued decrease in the difference in cost of electricity relative to fuels are expected to result in a much greater

use of electric power per capita in the Northeast between 1965 and 2000.

Thus, the most rapid growth in electricity generation is projected for the Northeast, where the relatively slow population growth is offset by an increase in per capita consumption from 37 percent below the national average in 1965 to only 5 percent in 2000. Per capita consumption in the Far West and the South, both well above the national average in 1965, is projected to grow at about the same rate as the national average, but because of the more rapid population increase in the Far West, generation requirements are expected to increase at a faster rate than in the South. A rate of population increase similar to that in the Northeast, but a slower rate of increase in per capita consumption, will result in smaller percentage increases in electricity generation in the North Central States than in either the Northeast or Far West.

In the Far West, California accounts for the largest share of the region's electricity generation, and this share is projected to increase between 1965 and 2000 -- a result of rapid population growth and a large increase in per capita consumption. Generation requirements in other western States, such as Washington and Oregon, which have had very high per capita consumption in the past, are projected to increase much less rapidly in the future (table 43).

Table 43. Generation of Electricity, by Region, 1965 and Projected 1980 and 2000

(in billion kilowatt hours)

Region	1965b/ (actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
United States a/......	1,157.1	2,643.0	2,780.0	2,870.0	5,463.0	6,087.0	6,688.0
Northeast..........	210.3	533.9	561.3	579.0	1,169.1	1,322.8	1,431.2
North Central......	306.9	695.1	732.1	754.8	1,414.9	1,574.6	1,732.2
South a/..........	420.9	906.5	953.8	984.4	1,764.5	1,964.0	2,160.2
West a/	215.6	499.5	525.4	542.4	1,067.1	1,211.3	1,330.9
Montana...........	8.9	11.5	12.1	12.5	20.7	23.0	25.3
Idaho.............	6.8	12.5	13.1	13.6	22.8	25.4	27.9
Wyoming...........	3.7	5.0	5.3	5.4	8.7	9.7	10.6
Colorado..........	8.2	24.5	25.7	26.6	54.3	60.6	66.5
New Mexico........	8.7	13.0	13.7	14.1	33.7	37.6	41.3
Arizona...........	9.9	26.4	27.8	28.7	65.2	72.7	79.9
Utah..............	4.3	13.5	14.2	14.6	31.5	35.1	38.6
Nevada............	3.5	10.5	11.0	11.4	18.5	20.6	22.6
Washington........	50.3	60.9	64.1	66.2	104.4	116.3	127.8
Oregon............	17.1	36.0	37.8	39.0	63.1	70.2	77.2
California........	94.2	285.7	300.6	310.3	644.2	740.1	813.2

a/ Includes Alaska and Hawaii.
b/ 1965 data represent electric power generated in the State or region and are not, therefore, comparable with the projections of generation requirements by State.

Source: 1965 data from [7].

CHAPTER VI

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CHAPTER VII

LUMBER, PANEL, AND WOODPULP PRODUCTS

This chapter provides projections of the consumption of softwood and hardwood lumber products, veneer and plywood products, and woodpulp products in the United States in 1980 and 2000. Included are total apparent consumption, exports, and the estimated domestic production of timber expressed in roundwood equivalents.

For the most part, recent analyses by the U.S. Forest Service have been used as a basis for the development of new projections [3, 4]. The statistics employed in the Forest Service studies have been updated or revised in accord with recent findings, the procedures used have been modified where necessary, and the assumptions have been evaluated and adjusted to agree with the projections of economic aggregates presented in Chapter II.

The Forest Service analyses rest on fundamental assumptions about population, the number of households, the size of the gross national product and of disposable personal income, and the relative prices of timber products. These assumptions have been adjusted and revised to conform with the projections of aggregates provided in other parts of this study. The population estimates presented in Chapter II are lower than the Forest Service estimates, whereas the range of estimates of GNP used in this study is consistently higher than the GNP estimates of the Forest Service.

The Forest Service study assumes that future relative prices of timber products will be more or less constant (i.e., with respect to competing materials), and that price-induced substitution of other materials will be limited. This assumption depends in large part on assumptions that stumpage supplies will be sufficient throughout the projection period to keep prices from rising relative to other goods as demand increases, and that technological progress in the forest industries will keep pace with that in industries producing competing materials. The Forest Service makes no general assumption about the impact of nonprice factors, although it recognizes such factors in the discussion regarding kindred products.

In the present study, it is assumed that price-induced substitutions are generally reflected in the 1948-65 trends, and that the extension of these trends implies a continuation of past rates of substitutions. Given the past trends, it is expected that price-induced substitutions will be less important in the future for plywood and veneer than for lumber, and least important for woodpulp products. Technological changes, particularly in relation to construction methods, will probably reduce the demand for lumber and, to a lesser extent, for plywood. Also, prefabrication, steel frames, and concrete foundations and walls will become increasingly important in the future.

The medium projection of timber consumption in the United States in 1980 is 18.9 billion cubic feet of roundwood, and 23.8 billion cubic feet in 2000. This compares with an estimated consumption of 13.5 billion cubic feet in 1962 (table 44).

The consumption of woodpulp products is projected to increase by 250 percent between 1962 and 2000, and to account for over 80 percent of the incremental demand for timber. Veneer and plywood products are projected to treble in output, but the consumption of lumber products is expected to increase by only 5 percent during the same period.

In 1962, net imports of timber were 1.5 billion cubic feet of roundwood, or 11 percent of all timber consumed. By 1980, net imports are projected to increase to 1.8 billion cubic feet, and by 2000, to 2.8 billion cubic feet. Even in 2000, therefore, over 89 percent of timber consumption will come from domestic resources. The bulk of the increase in imports is expected to be products derived from pulpwood.

The relative importance of hardwood and softwood is also expected to change. In 1962, 80 percent of domestic timber consumed was softwood (excluding "other" consumption). Hardwoods are projected to account for 35 percent of domestic production in 1980, and 30 percent in 2000, excluding "other" consumption (table 45). Most of the additional hardwood used will be for pulpwood production.

In 1965, 632 million cubic feet of wood products were exported from the United States, compared with 134 million

Table 44. Domestic Consumption Of Timber in the United States, 1962 and Projected 1980 and 2000

(billion cubic feet, roundwood equivalent)

Timber product	1962 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Lumber.........	5.9	6.2	6.5	6.7	4.6	6.2	6.4
Softwood......	4.7[a]	5.0	5.2	5.3	3.7	5.0	5.1
Hardwood......	1.2[a]	1.2	1.3	1.3	0.9	1.2	1.3
Veneer and plywood	1.0	1.9	2.0	2.1	2.2	3.1	3.3
Softwood......	0.9[a]	1.7	1.8	1.8	1.9	2.7	2.9
Hardwood......	0.1[a]	0.12	0.2	0.3	0.3	0.4	0.4
Wood pulp......	4.1	8.0	8.5	9.2	12.0	13.1	14.5
Softwood......	2.9[a]	5.4	5.7	6.2	7.8	8.5	9.4
Hardwood......	1.2[a]	2.6	2.8	3.0	4.2	4.6	5.1
Other[b].........	2.5	1.9	1.9	1.9	1.4	1.4	1.4
Softwood......	0.9[a]	0.7	0.7	0.7	0.5	0.5	0.5
Hardwood......	1.6[a]	1.2	1.2	1.2	0.9	0.9	0.9
Total..........	13.5	18.0	18.9	19.9	20.2	23.8	25.6
Softwood......	9.4	12.8	13.4	14.1	13.9	16.7	17.9
Hardwood......	4.1	5.2	5.5	6.8	6.3	7.1	7.7

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a/ Estimated.

b/ Fuel wood and miscellaneous industrial uses.

Source: 1962 data from [3].

Table 45. Domestic Production of Softwood and Hardwood, 1962 and Projected 1980 and 2000

(billion cubic feet of roundwood)

Timber product	1962 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Lumber							
Softwood......	4.20	4.40	4.70	4.90	3.40	4.50	4.60
Hardwood......	1.05	1.20	1.20	1.20	0.80	1.10	1.20
Veneer and plywood							
Softwood......	0.71	1.40	1.50	1.60	1.60	2.20	2.40
Hardwood......	0.15	0.20	0.20	0.20	0.20	0.30	0.30
Woodpulp							
Softwood......	2.61	4.80	5.10	5.50	6.30	7.00	7.70
Hardwood......	0.68	2.30	2.50	2.70	4.20	4.50	5.00
Other[a]							
Softwood......	0.60	0.70	0.70	0.70	0.50	0.50	0.50
Hardwood......	1.70	1.20	1.20	1.20	0.90	0.90	0.90
Total							
Softwood......	8.02	11.30	12.00	12.70	11.80	14.20	15.20
Hardwood......	3.88	4.90	5.10	5.30	6.10	6.80	7.40

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[a] Fuel wood and miscellaneous industrial uses.

Source: 1962 data from [3].

in 1950. Logs, lumber, and, increasingly, pulp have made up the bulk of the exports in recent years. Softwood accounted for 80 percent of the total. About four-fifths of the logs and one-third of the lumber were exported to the Far East. Most paper and board was sent to Western Europe, together with one-third of the lumber.

The recent rapid rate of growth in exports is not expected to continue. Exports are projected to range between 1.0 and 1.2 billion cubic feet in 1980, and between 1.5 and 2.0 billion cubic feet in 2000 (table 46). The Far East receives a large share of the exports. However, overcapacity of U.S. plants has stimulated the export of paper and board to Europe and Latin America in recent years, and it is possible that further inroads may be made into these markets, which are expanding rapidly. Lumber exports are projected to increase, but more slowly than woodpulp products.

Consumption of Lumber and Panel Products

The consumption of lumber, veneer, and plywood was projected by reviewing the outlook for each of the various major end products in which these commodities are used, and calculating the quantities which will be required to meet expected levels of consumption. Regression equations based on the historic data on timber consumption and general economic indicators were considered to be an inadequate basis for production since changes in consumer habits and the innovational changes among competing products are expected in some importtant uses over the next 50 years.

The major end-product groups reviewed were construction, manufactured products, shipping and handling materials, and a miscellaneous category which represents a relatively minor residual of products (table 47).

Construction

In considering the consumption of lumber and panel products for construction purposes, there are six kinds of use which are different enough to warrant special treatment. By far the most important, in respect to lumber use, is residential construction. The others uses are nonresidential construction, upkeep and improvements, farm structures, railroad building and repair, and mining.

Table 46. Exports of Wood Products, 1965 and Projected 1980 and 2000

(in billion cubic feet)

Timber product	1965 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Lumber...........	0.35	0.49	0.54	0.58	0.71	0.83	0.95
Softwood.........	0.31	0.43	0.48	0.51	0.63	0.73	0.84
Hardwood.........	0.04	0.06	0.06	0.07	0.08	0.10	0.11
Veneer and plywood	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Softwood.........	a/						
Hardwood.........	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Pulpwood..........	0.27	0.50	0.55	0.60	0.77	0.90	1.03
Softwood.........	0.02	0.37	0.41	0.44	0.57	0.67	0.76
Hardwood.........	0.07	0.13	0.14	0.16	0.20	0.23	0.27
Total.............	0.63	1.00	1.10	1.20	1.50	1.75	2.00
Softwood.........	0.51	0.80	0.89	0.95	1.20	1.40	1.60
Hardwood.........	0.12	0.20	0.21	0.25	0.30	0.35	0.40

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a/ Negligible

Source: 1965 data from [1].

Table 47. Consumption of Lumber, Veneer, and Plywood in the United States by End Use, 1962 and Projected 1980 and 2000

(billion board feet)

End Use	Lumber							Veneer and plywood						
	1962 (Actual)	1980			2000			1962 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High		Low	Medium	High	Low	Medium	High
Construction														
Residential......	13.96	15.2	15.9	16.4	10.0	13.5	13.9	4.17	6.9	7.4	7.6	8.0	11.3	11.9
Nonresidential...	5.00	6.0	6.3	6.5	4.6	6.2	6.4	2.80	5.8	6.2	6.4	7.1	10.1	10.7
Upkeep & improvements..........	5.40	5.9	6.2	6.4	4.8	6.5	6.7	1.50	3.2	3.4	3.5	3.4	4.8	5.1
Farming.........	2.00	0.9	1.0	1.0	0.5	0.7	0.7	0.21	0.4	0.4	0.4	0.4	0.6	0.6
Railroads.......	0.94	1.1	1.2	1.2	0.9	1.2	1.2	0.05	0.1	0.1	0.1	0.1	0.1	0.1
Mining..........	0.33	0.3	0.3	0.4	0.3	0.4	0.4	-	-	-	-	-	-	-
Manufactured products	4.24	4.4	4.6	4.7	3.7	4.9	5.1	1.87	3.2	3.4	3.5	3.7	5.3	5.6
Shipping & handling materials........	4.34	5.2	5.5	5.7	4.1	5.5	5.7	1.22	1.7	1.8	1.9	1.6	2.2	2.3
Misc. & residual..	1.09	1.0	1.1	1.1	0.8	1.1	1.2	0.20	1.6	1.7	1.8	2.2	3.1	3.3
Total..........	37.20	40.2	42.2	43.7	29.7	40.0	41.3	12.02	22.8	24.4	25.2	26.4	37.5	39.6
Softwood.....	29.75	32.2	37.7	34.8	23.8	32.0	33.0	9.92	20.0	21.6	22.4	23.6	33.0	3.5
Hardwood.....	7.45	8.1	8.5	8.7	6.0	8.0	8.3	2.10	2.8	2.8	2.8	2.8	4.5	4.5

Source: 1962 data from [3].

Residential Construction

The consumption of lumber and panel products in residential construction depends on the number of new dwelling units, the number of replacements, and the amount of wood used per type of new dwelling unit or replacement.

The total number of dwelling units in 1980 and 2000 was estimated by assuming that each household would occupy a dwelling unit and that 10 percent of all units would be vacant. The number of new dwelling units was derived by assuming that the average annual rate of increase of new dwelling units would be constant from 1960 to 1980 and 1980 to 2000, and the estimates for replacements were based on those used in Timber Trends [3]. The projected composition of housing units (single- or multifamily units) was based on an extrapolation of recent trends.

The amount of lumber consumed per dwelling unit constructed has been declining in recent years. This downward trend is expected to continue, due primarily to substitution of plywood and nonlumber products in dwelling units. By 2000, dwelling units may be constructed by methods that differ greatly from those used today. The Timber Trends estimate for 1980 has been used in this report, but a somewhat smaller amount of lumber per unit has been estimated for 2000. It is expected, for example, that prefabrication of both single- and multifamily homes will reduce the demand for lumber for framing and other uses. Concrete foundations, walls and panels; steel frames; and plywood for sheathing and other nonstructural uses have reduced the demand for lumber per unit. The use of veneer and plywood per dwelling unit has been increasing and is expected to continue to show an upward trend until 2000.

The medium projections of lumber used for residential construction in 1980 and 2000 are 15.9 and 13.5 billion board feet, respectively. The most likely level of consumption of veneer and plywood is projected to be 7.4 billion square feet in 1980 and 11.3 billion in 2000 (table 47).

Nonresidential Construction

Nonresidential construction includes industrial, commercial, and other buildings, as well as public utilities, highways, military facilities, and sewer and water facilities. The only common measure of such activity for which historical data are available is total dollar expenditures by construction class. The procedure used in Timber Trends has been followed here. First, an estimate was made of the dollar value (1961 dollars) of new nonresidential construction in 1980 and 2000. Second, the quantities of lumber, veneer, and plywood used per dollar of construction expenditure were estimated for 1980 and 2000.

The estimates of expenditures for new nonresidential construction in 1980 and 2000 were based partly on extrapolations of recent data and partly on the estimates of GNP and population in Chapter II of this study.

The decline in the consumption of lumber per dollar expenditure is projected to continue. The Forest Service estimate for 1980 has been used, but a somewhat lower figure is projected for 2000. The price induced substitution of nonlumber products and plywood for lumber is expected to take place at a more rapid rate than was assumed in Timber Trends [3]. The use of plywood and veneer per dollar of expenditure for nonresidential construction has been increasing in recent years, and is projected to continue to do so.

The medium projection of lumber to be consumed in nonresidential construction in 1980 is 6.3 billion board feet. The medium projection for 2000 is 6.2 billion board feet. In contrast, the medium projections for veneer and plywoods reflect expectations of large increases in the use of panel products. The most likely estimates of veneer and plywood consumption are 6.2 billion square feet in 1980 and 10.1 billion in 2000 (table 47).

Upkeep and Improvements

Included in this sector are all uses of wood for repair and upkeep of residential and nonresidential structures (excluding farms and railroads). Although the total inventory of structures will increase, the emphasis on replacement, rather than repair, and the substitution of nonlumber products and plywood will limit consumption of lumber for this use in the future.

Displacement of lumber by plywood and new plywood products that can compete effectively with plastics are expected to result in a substantial increase in the consumption of plywood and veneer for repairs.

The medium projections of lumber and panel products for these uses in 1980 are 6.2 billion board feet of lumber and 3.4 billion square feet of veneer and plywood. The projections for 2000 are 6.5 billion board feet of lumber and 4.8 billion square feet of panel products (table 47).

Farm Structures

The quantity of wood used in nonresidential farm building is projected to decline between 1962 and 2000. The Forest Service projected an increase in construction expenditures, but since 1961 there has been a steady decline in the amount spent, and this downward trend has been projected to continue.

As in other sectors, the amount of lumber used per dollar of expenditure will also decline because of substitution and changes in construction techniques. A considerable increase is projected for the use of veneer and plywood per dollar of expenditure, however. The medium projection of lumber used for farm structures in 1980 is 1 billion board feet, and for panel products, 0.4 billion square feet. The projections for 2000 are 0.7 billion board feet and 0.6 billion square feet, respectively (table 47).

Railroad Building and Repair

Crossties and the construction and repair of railroad cars are the leading consumers of lumber and plywood in this category. The decline in rail mileage of recent years and the current rate of replacement of crossties is expected to continue in the future. Annual consumption of lumber in both 1980 and 2000 was projected by the Forest Service at 1.2 billion board feet of lumber, and at 0.1 million square feet of plywood and veneer, and these projections have been used in this study. All of the projected consumption of plywood and veneer will be used in railroad cars, together with about one-sixth of the lumber.

Mining

The use of lumber in mines has been declining steadily but is projected by the Forest Service to remain at the 1962 level of 330 million board feet in 2000. These projections have been used as the medium projections in this report (table 47). More than double the output of coal by 2000 and increases in the production of underground ores are expected to offset further declines in the uses of wood per ton of output.

Manufactured Products

Manufactured products ranging from furniture and other consumer goods to industrial machinery are included in this category. The Forest Service projection for 1980 of 4.6 billion board feet of lumber has been used as the medium projection in this report. By 2000, however, lower unit consumption of lumber is expected to result in total lumber consumption of 4.9 billion board feet, somewhat less than that predicted in Timber Trends. Recent data indicate that whereas industrial production is increasing more rapidly than was projected by the Forest Service, unit consumption of lumber is decreasing at a faster rate because of increases use of panel products and nonlumber products such as plastics.

As in most other sectors, the use of plywood and veneer in manufactured products is projected to increase more rapidly than was estimated in Timber Trends. The medium projections for the use of plywood and veneer in 1980 and 2000 are 1.9 and 5.3 billion square feet, respectively (table 47).

Shipping and Materials Handling

There are three major uses of lumber, veneer, and plywood in shipping and materials handling: dunnage, pallets, and boxes and crates.

Dunnage is wood, mostly lumber, used to brace and protect items in transit. A reduction in the use of dunnage in the future, due to more efficient use of materials for packaging and developments in materials-handling methods, will be offset by the increase in shipments. The Forest Service estimates of 1 billion board feet in 1980 and 1.1 billion in 2000 have been used. These compare with an estimated consumption of 840 million board feet in 1962.

The use of pallets for shipping has increased rapidly in recent years at the expense of boxes and crates. This trend is expected to continue in the future, as palletized systems of handling products replace other storage and handling methods. In 1980 the consumption of lumber for pallets is projected to reach 3.5 billion board feet, compared with 1.7 billion board feet estimated for 1962. By 2000, consumption is projected at 3.8 billion cubic feet. These projections are somewhat higher than those of the Forest Service because of the more rapid rate of substitution for boxes and crates expected, and the higher GNP used in this study.

Boxes and crates have consumed a decreasing amount of lumber in recent years and this downward trend is expected to continue. Compared with an estimated consumption of 1.8 billion board feet of lumber in 1962, boxes and crates are projected to use only 1 billion in 1980 and 700 million in 2000.

The most likely projection of lumber used for shipping is 5.5 billion board feet in both 1980 and 2000. Plywood and veneer, which account for only about one-fifth of the consumption of wood for shipping, are not projected to increase significantly. The use of these products for shipping is projected to be 1.8 billion square feet in 1980 and 2.2 billion in 2000 (table 47).

Miscellaneous and Residual Uses

Consumption of lumber in this sector has been projected to remain at the 1962 level of 1.1 billion board feet in both 1980 and 2000. The use of plywood and veneer is projected to increase from 200 million square feet in 1962 to 1.7 billion in 1980 and 2.1 billion in 2000 (table 47).

Consumption of Woodpulp Products

The medium projection of the consumption of woodpulp products indicates an increase from 4.8 billion cubic feet of roundwood in 1965 to 8.5 billion in 1980 and 13.1 billion in 2000. Net imports provided 16 percent of the woodpulp products required in 1965, but their share is projected to decline to 12 percent by 2000 (table 48).

With improvements in pulping processes, the manufacture of pulp from hardwood has become increasingly important. In 1965 about 30 percent of the pulpwood consumed in U.S. mills was hardwood. By 1980, nearly half the pulpwood consumption is projected to be supplied from hardwood, and in 2000, almost two-thirds will be hardwood.

Determinants of Pulpwood Consumption

The consumption of woodpulp products is determined by (1) the demand for paper and board and other products consuming woodpulp;[1] (2) the total amount of fibrous material required to produce the paper and board requirements and the proportion of this total that comes from woodpulp, waste paper, or any other fiber; and (3) the requirements for different types of woodpulp and the amount of pulpwood consumed in the processing of each type of woodpulp.

Paper and Board Consumption

Consumption of paper and board has increased rapidly in recent years, and the Timber Trends projections for 1970 were passed by 1966 for almost every type of product. More recent projections by the Forest Service [4] for 1970-85 show much higher rates of consumption. These projections were derived from regression equations that related trends in per capita consumption for each type of paper and board to an independent variable, such as GNP, disposable personal income, and the FRB index of industrial production. The Forest Service projections have been used as the basis for the projections of paper and board in 1980 in this report, adjusted to take account of a higher GNP and disposable personal income (table 49). The trends indicated by the Forest Service have also been extrapolated and used as a basis for the projections of consumption in 2000.

The consumption of board is projected to increase more rapidly than paper due to the increasing use of container

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[1] There is small consumption of woodpulp for highly refined products, such as cellophane and other fibers.

Table 48. Consumption of Woodpulp Products, 1965 and Projected 1980 and 2000

(in billion cubic feet)

Item	1965 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Production in U.S. mills....	4.0	7.1	7.6	8.2	9.7	10.5	11.5
Softwood.....	2.8[a]	4.8	5.1	5.5	6.3	7.0	7.7
Hardwood.....	1.2[a]	2.3	2.5	2.7	4.2	4.5	5.0
Net imports....	0.8	0.9	0.9	1.0	1.5	1.6	1.8
Softwood.....	0.7[a]	0.6	0.6	0.6	1.0	1.1	1.2
Hardwood.....	0.1[a]	0.3	0.3	0.4	0.5	0.5	0.6
Total.........	4.8	8.0	8.5	9.2	12.0	13.1	14.5
Softwood.....	3.5[a]	5.4	5.7	6.1	7.3	8.1	8.9
Hardwood.....	1.3[a]	2.6	2.8	3.1	4.7	5.0	5.6

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[a] Estimated.

Source: 1965 data from [4].

Table 49. Consumption of Paper and Board, 1965 and Projected 1980 and 2000

(Million tons)

Use	1965 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Paper.............	26.6	42.9	47.0	49.6	68.2	73.1	79.4
Newsprint.......	8.4	12.1	13.3	14.0	17.5	18.8	20.4
Book paper......	5.0	9.1	10.0	10.7	16.4	17.6	19.1
Coarse and industrial.....	5.5	8.3	9.1	9.6	12.7	13.7	14.8
Other..........	7.7	13.4	14.6	15.3	21.6	23.0	25.1
Board.............	22.3	40.1	44.0	46.4	71.8	76.9	83.6
Containers......	11.3	21.7	23.8	25.1	39.9	42.8	46.5
Bending.........	5.4	9.5	10.5	11.0	17.5	18.8	20.4
Other...........	5.6	8.9	9.7	10.3	14.4	15.3	16.7
Total.........	48.9	83.0	91.0	96.0	140.0	150.0	163.0
Net imports.	5.1	9.4	9.6	10.4	17.5	18.3	20.4

Source: 1965 data from [4].

board and, to a lesser extent, bending board. Newsprint is expected to remain the most important type of paper produced, but its share of the total paper production is projected to decline, and the shares of both book paper and tissues to increase (table 49).

Net imports in 1965 were 5.1 million tons and, according to the medium projections, will increase to 9.6 million tons in 1980 and 18.3 million tons in 2000 (table 49). Most of these imports will be in the form of newsprint from Canada.

A little over 1 ton of fibrous material is required to manufacture each ton of paper or board.[2] In 1965, 76 percent of all fibrous material consumed for paper and board was woodpulp from new wood. Waste paper supplied another 22 percent, and the rest came from rags, straw, and other fibers. The proportion of woodpulp used relative to waste paper has been increasing. This is in part due to a trend towards greater use of woodpulp in the manufacture of most kinds of paper and board and in part to the rapid growth of those sectors which use only woodpulp or very small quantities of other material. In 1980 it is estimated that all but 18.5 percent of the fibrous material will be from woodpulp, and all but 15 percent in 2000 (table 50).

The amount of pulpwood consumed to supply the woodpulp requirements depends on the pulping process which, in turn, depends on the type of paper or board being manufactured. For example, sulfate pulps (three-fifths of the pulp produced in 1965) consume about 1.5 cords of pulpwood for each ton of woodpulp produced.

The estimates for each type of pulp shown in table 51 are based on the recent Forest Service estimates.

In 1965, the average amount of pulpwood consumed to produce a ton of woodpulp was 1.5 cords. The projections for 1980 and 2000 are shown below:

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[2] Estimated at 1.05 tons of fibrous material for one ton of paper and board in 1980 and 2000.

Table 50. Fibrous Material and Woodpulp Consumed for Paper and Board, 1965 and Projected 1980 and 2000

Item	1965 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Fibrous material (mil. tons).....	45.1	77.3	81.4	85.6	122.5	133.7	142.6
Woodpulp (mil. tons)..........	34.2	63.0	66.3	69.8	104.1	111.9	121.2
Percent of fibrous material........	75.8	81.5	81.5	81.5	85.0	85.0	85.0

Source: 1965 data from [4].

Table 51. Consumption of Woodpulp by Type, 1965 and Projected 1980 and 2000

(million tons)

Types of woodpulp	1965 (Actual)	1980 Low	1980 Medium	1980 High	2000 Low	2000 Medium	2000 High
Dissolving and special alpha......	1.2	1.8	1.9	2.0	1.6	1.7	1.8
Sulfite............	3.3	3.3	3.4	3.6	3.1	3.4	3.6
Sulfate and soda.....	21.9	42.4	44.6	47.0	74.4	80.0	86.6
Groundwood..........	4.3	5.9	6.2	6.6	7.3	7.8	8.5
Semichemical........	2.9	7.6	8.0	8.5	15.6	16.8	18.2
Defibrated, exploded, and screenings.....	1.5	2.0	2.1	2.2	2.1	2.2	2.4
Total.............	35.0	63.0	66.3	69.8	104.1	111.9	121.2

Source: 1965 data from [4].

	Pulpwood consumed per ton of woodpulp (cords)
1980	
Low	1.475
Medium	1.5
High	1.525
2000	
Low	1.35
Medium	1.357
High	1.4

Improvements in processing techniques are expected to result in a slight decline in the amount of pulpwood consumed per ton of woodpulp produced.

Exports of Wood Products

Exports of wood products (logs; pulpwood; the roundwood equivalents of lumber, veneer, and plywood; and pulp and paper) are particularly difficult to forecast. Export markets are influenced strongly by political as well as by economic considerations. Moreover, some of the economic issues are of a sort which are neither important nor common in national markets. For example, unpredictable variations in international rates of exchange, complications peculiar to ocean-borne shipping, and tariff regulations create uncommon variations. National policies with regard to support for the underdeveloped countries sometimes run counter to the interests of industries seeking protection against competition from foreign commodities. Other policies to build local industry may, in some cases, delay development of exports. This last situation is exemplified by the timber of Alaska, which cannot be shipped without some processing.

Consequently, forecasts must be strongly qualified. The evaluation which follows will serve primarily to point up recent trends and to illuminate a few of the major forces which currently seem to be affecting these trends.

In general, pulpwood, veneer, and plywood exports have been small during the period studied. Logs, lumber, pulp, and to an increasing extent, paper and board, have made up the bulk of the exports. Softwoods continue to represent more than three-fourths of the total.

The big increases in recent years have been in exports of logs and pulp. They currently represent about three-fifths of all exports. Much of this semiprocessed wood (four-fifths of the logs and one-third of the pulp) goes to the Far East. In contrast, the bulk of the paper and board and about one-third of the lumber currently go to Western Europe and Latin America. Recent trends may be interpreted as follows:

(1) Lumber exports appear to be guided by a philosophy of "maintenance of established markets," leading to low growth rates, and with little chance for great fluctuations in year-to-year sales because of the diverse lumber markets.

(2) For veneer and plywood, the prospects for rapid growth of exports seem limited by the local supply situation in the United States and the adequacy of raw materials in many parts of the world, by the relatively low investment needed to establish the industry and by its relatively high utilization of labor.

(3) Paper and board, particularly container board, find markets in the advanced economies of Western European countries and in the emerging areas in Latin America. In part, recent export trends are a result of tendency toward overcapacity in U.S. industry, but these markets tend to be retained, and as the industry learns to trade abroad and expands its interests in the export field, prospects for more substantial export trade increase.

(4) The log and pulp markets, both because they are highly concentrated as to destination and because they raise the additional question of relative advantage or disadvantage of exporting unprocessed or only partly processed materials, tend to be somewhat more volatile than other markets. Because of the relative importance of log and pulp markets in the wood export field, prospects for their development will greatly influence the total export picture.

If present trends continue, total exports would approximate 2 billion cubic feet by 1980, compared with 700 million cubic feet in 1966, and would represent 30 to 40 percent of domestic log production by the end of the century. Consideration of the trends for individual commodity groups and the tendencies for development noted above, however, indicate that extrapolations of the current trend yields levels are unrealistically high. The prospects, based on individual trend

estimates, are for 1,000 to 1,200 million cubic feet of exports in 1980, and 1,500 to 2,000 million cubic feet in 2000 (table 46). The export market is expected to be split fairly evenly between lumber products and woodpulp products.

CHAPTER VII

LITERATURE CITED

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CHAPTER VIII

OUTDOOR RECREATION

The demand for outdoor recreation is considered in terms of visits to Federal recreation lands and State parks, outdoor recreation participation occasions, and fishing and hunting licenses. Whenever possible, projections of outdoor recreation activity were based on the trends observed between 1948 to 1965.

In 1965, for the first time in this century more land was reserved for open-space recreation than for building purposes. This reservation of land is a reflection of the demand for recreation which, in turn, is a function of the growth of the Nation's population, the rising standard of living, greater per capita disposable personal income, increasing amounts of leisure time, increasing metro-urbanization, an increasingly mobile population, and new and changing concepts of the role of recreation and its institutions.

The measure of the demand for outdoor recreation on Federal and State lands used in this study was the number of visits per 100 population. No attempt was made to forecast the additional acreage needed to serve the future demand for outdoor recreation facilities, nor were specific problems of administration and development of public recreation areas by public agencies considered. Whether roads into virgin areas, such as in the Great Smokey Mountain National Park, will be constructed to accommodate the growing demand, or whether these areas will remain in their present state of development, is a public policy matter. No attempt was made in this study to anticipate such policy decisions.

Visits to four classes of Federal lands in the contiguous United States were projected: national parks, other areas administered by the National Park Service (e.g., historical sites, seashores, monuments, etc.), national forests, and wildlife refuges. It should be noted, however, that the four classes of land considered accounted for less than 50 percent of the Federal recreation attendance in both 1960 and 1965. Other Federal lands with recreational activities include areas administered by the Army Corps of Engineers and the Tennessee Valley Authority (table 52). It would be misleading, therefore, to assume that increased visits to these four classes

Table 52. Visits to Federal Recreation Areas in the United States, by Agency, 1960 and 1965

Agency	1960		1965		Percent increase 1960-65
	Number (millions)	Percent	Number (millions)	Percent	
Total...........	383.9	100	597.9	100	56
National Park Service.......	72.3	19	121.3	20	68
Bureau of Sport Fisheries and Wildlife......	10.8	3	12.9	2	19
Bureau of Land Mgt......	17.1	5	27.2	5	59
Bureau of Reclamation...	24.3	6	36.5	6	50
Forest Service.......	92.6	24	160.3	27	73
Army Corps of Engineers.....	109.0	28	168.6	28	55
Tennessee Valley Authority.....	42.3	11	49.4	8	17
Other[a/]........	15.5	4	21.7	4	40

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a/ Army, Navy, and Air Force.

Source: U.S. Bureau of Outdoor Recreation, unpublished data.

of land will account for all of the recreational activities on Federal lands in the future. The projections imply increased supply of facilities in response to demand, without attempting to prejudge Federal actions in the future, i.e., future visits have been projected, not predicted.

Definitions

In 1964, the President's Advisory Council on Recreation and Natural Beauty directed--

> All Federal agencies responsible for administration of recreation use on public lands [to] report on the volume of that use in terms of visitor-days. The visitor-day unit reflects the elapsed time which visitors spend in various recreation pursuits, with any combination of time aggregating 12 hours of activity being considered as one visitor-day [7].

The visitor-day, as a unit of measurement, is extremely useful insofar as it allows an accurate computation of recreation use of Federal lands. However, since recreation-use statistics estimated prior to 1965 were made in terms of numbers of visits rather than visitor days, the visit unit of measurement was used for the projections made in this study. A visit is defined as a person in attendance at a national park or some other recreational facility without reference to the duration of his attendance.

This study was confined to areas in the contiguous United States. However, population data after 1950 used in the national projection tables included Alaska and Hawaii. Thus, in the projections of national recreation visits, the Alaskan and Hawaiian populations were included.

In Chapter IX of this study, the quantity of land that will be used for urban growth is discussed. As indicated in that chapter, by 2000 several continuous ribbons of development will link most United States Standard Metropolitan Statistical Areas (SMSA's) [4]. Populations of the SMSA's of the 1960's have not experienced the lack of nearby rural areas that will be common in 2000, and it is essential to account for this type of urbanization to understand the demand for outdoor recreation in the future. The term metro-urbanization is used in this study to refer to such urban development. Measures of metro-urbanization are based on the past average annual growth rates in SMSA's. By 2000, more than 70 percent of the U.S. population will be residing in metro-urban areas.

Recreational Activity on Federal Lands

In projecting recreational activity on Federal lands, it was not possible to determine the regional origins of visitors since regional data for past visits by regional origin of visitors is not available, some national parks and forests are located in two or more States, and the regional distribution of Federal recreation land is changing. For these reasons, only national projections were made for visits to Federal lands used for recreation.

Multiple regression equations were used to explain past visits and to determine future visits to each of the four Federal areas considered in the study (national parks, other NPS areas, national forests, and wildlife refuges). The determinants of visits in the past were: (1) per capita real disposable income, (2) per capita intercity automobile travel, (3) weekly hours of leisure per employed person, and (4) changing recreation preferences.1/ While these determinants are usually adequate to explain the past, they are less reliable in projecting outdoor recreation requirements. The Bureau of Outdoor Recreation (BOR) [5] survey of recreation demand revealed, for instance, that once certain levels of income, leisure, and mobility have been reached, they are no longer the factors that influence recreation visits to specific areas. Changing recreation preferences, measured by increased visits to wildlife refuges and national forests over time and related to income, are the only variables that appear to yield realistic projections of future demand.

Changes in the patterns of visits to specific recreation areas must be considered in terms of contributing factors. Metro-urbanization may be one such factor -- the lack of undeveloped rural-natural areas near population centers plus increased urban concentrations will add to the lure of the wilderness characteristics of national parks and national monuments. Another factor is probably increased education. As the general education level increases in the United States and as metro-urbanization increases, these wilderness areas may become natural laboratories -- the only places where nature can be studied. Finally, a factor which is difficult to quantify, but is nevertheless important, is the psychological need of urban dwellers to find periodic relief from the pressures of a congested urban environment.

A summary of the projections of visits to national parks, other areas administered by the National Park Service, national forests, and wildlife refuges is shown in table 53.

National Parks

In 1948, there were 26 national parks listed in the 48 States. Petrified Forest, Arizona, formerly a national monument, became a national park in 1964, and in 1965 Canyonlands, Utah, was added, giving the continental United States 28 national parks. Nearly 11 million park visits were recorded in 1948, and by 1965 there were almost 36 million visits. Although the national population increased during the period, visits per 100 population far outpaced the population growth, rising from 7.46 per 100 population in 1948 to 18.51 in 1965.

In projecting demand to 1980 and 2000, the variable of time, reflecting changing recreation preferences, metro-urbanization education, and psychological needs, yielded the most realistic projections. Visits to national parks are projected to be 35.72 per 100 population in 1980 and 70.76 in 2000, or to almost double in the coming 15 years (1980), and to double again in the next 20 years (2000). The medium projections of park visits for 1980 and 2000 are 84.0 million and 217.8 million, respectively (table 53).

Other Areas Administered by the National Park Service

In projecting visits to National Park Service (NPS) administered areas other than national parks,2/ only those

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1/ Outdoor Recreation Resources Review Commission staff methodology was used as a model in our original projections. [1, Vol. 26, Ch. 2].

2/ NPS administered areas include national parks, battlefields, battlefield parks, battlefield sites, cemeteries,

Table 53. Recreational Visits to National Parks and Other Areas Administered by the National Park Service, National Forests, and Wildlife Refuges, 1964 and Projected 1980 and 2000

(millions of visits)

Recreation area	1964 (actual)	1980 Low	1980 Medium	1980 High	2000 Low	2000 Medium	2000 High
National parks..........	33.4	81.3	84.0	88.2	200.0	217.8	246.7
Other NPS administered areas..................	76.1	143.5	148.2	155.6	269.3	293.3	332.3
National forests........	132.4	419.2	433.0	454.6	880.2	958.7	1086.1
Wildlife refuges.........	13.9	38.6	39.8	41.8	71.5	77.9	88.2
Total..................	255.8	682.6	705.0	740.2	1421.0	1547.7	1753.3

Source: 1964 data from [7, 11] and U.S. Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, unpublished yearly summaries. These figures exclude Alaska and Hawaii.

areas located in the 48 contiguous States and the District of Columbia were considered.3/ In 1948, there were 131 such areas, and by 1965 the number of areas had increased to 156.

Whereas two-thirds of the national parks in the 48 States are located in the West, other NPS areas are widely distributed geographically. In addition to geographic distribution, other NPS areas were distinguished from national parks on the basis of the relative number of visits. These areas accounted for 63.5 percent of the total visits to NPS-administered areas in 1948, and by 1965 had increased to 70.4 percent. Many factors influenced this increase, including the relative proximity of these areas to urban populations and an increased awareness of the historical significance of many of the areas.

In absolute terms, the number of visits to NPS administered areas other than national parks increased from 18.56 million in 1948 to 82.30 million in 1965, or by 344 percent. In 1965, there were 42.47 visits per 100 population, compared with 12.70 in 1948.

For 1980, the projection of visits to other NPS areas is 63.02 per 100 population, and for 2000, 95.29 visits per 100 population. The medium projection of visits in 1980 is 148.2 million, and the projection for 2000 is 293.3 million (table 53).

National Forests

Recognizing the need to preserve forest resources, in 1891 Congress authorized the President of the United States to set aside a forest reserve, the forerunner of the national forests now administered by the Forest Service. By 1948, there were national forests in 38 of the 48 States, and by 1964, in 40 of the 48 States.

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historic sites, historic parks, memorials, memorial parks, military parks, monuments, recreation areas, seashores, parkways, and the Capital Park System.

3/ The White House was excluded because comparable data were not available prior to 1964.

The increase in visits to national forests, both total visits and visits per 100 population, has been rapid. In 1948, almost 24 million visits were recorded, and by 1965 there were more than 52 million visits annually. Visits per 100 population increased from 16.36 to 31.03 between 1948 and 1956. During the 8-year period, both the number of visits and the rate of visitations almost doubled, and it took but 6 years for this doubling to occur again, so that by 1962 there were more than 111 million visits, or 59.96 visits per 100 population.

This phenomenal growth can be explained in part by the geographic locations of national forests. There are more national forests than national parks in the densely populated areas of the United States, and they are more accessible to the populous East Coast and the densely populated centers of the North Central Region and the Far West.

In projecting national forest visits to 1980 and 2000, per capita disposable personal income and changing recreation preferences over time appeared to be the most important factors. A minimum level of income appears to be necessary in order to take advantage of recreational opportunities offered by the national forests. Once this level of income is attained, however, income becomes a much less important determinant of visits.

In 1965, there were 69.18 visits per 100 population to national forests. By 1980, the number of visits per 100 population can be expected to double the 1965 rate, and the number in 2000 is projected to be four times greater than 1965. The medium projections of total national forest visits for 1980 and for 2000 are 433.0 million and 958.7 million, respectively (table 53).

Wildlife Refuges

In 1903, Pelican Island, Florida, was designated as the first United States Wildlife Refuge, and was the beginning of the Wildlife Refuge System. An important purpose of the refuges is the protection of fish and wildlife in their natural habitats in designated areas.[4] In 1962, Congress

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[4] In 1965, there were refuges in every State, except Connecticut, Indiana, New Hampshire, Rhode Island, and West

authorized public recreation as a secondary use of the refuges, to the extent that such use is compatible with the primary purpose of the refuges, the protection of fish and wildlife.[5]

In 1951, there were 97 refuge areas, registering less than 3.5 million visitors. By 1964, there were 159 areas with nearly 14 million visits recorded, an increase in visits of more than 300 percent in the 13-year period. In 1964, the Bureau of Sport Fisheries and Wildlife noted that 70 percent of the 1964 visitors were sightseers, birdwatchers, picnickers, boaters, and swimmers.[6] The remaining 30 percent were fishermen (27 percent) and hunters (3 percent).

Per capita disposable income and changing recreation preferences were found to be the determinants of visits to wildlife refuges. In 1964, the visits per 100 population were 7.27. The estimated visits per 100 population are 16.94 in 1980, or more than double the number estimated for 1965. By 2000, projected visits are 25.30 per 100 population, an increase of about 50 percent in the 20-year period. The medium projections of visits to wildlife refuges are 39.8 million in 1980 and 77.9 million in 2000 (table 53).

Recreational Activity on State Lands

At the present time the number of visits to State parks is more than 10 times as great as visits to National parks, and visits to State parks increased at a greater rate than visits to National parks between 1960 and 1965.

	Millions of visits	
	1960	1965
National parks	25.8	35.9
State parks	293.8	420.5

Virginia. Distinction should be made between those areas which record visitor attendance and all areas. In 1964, there were 159 refuges reporting visitor attendance from a total of 297 units within the entire system [6].

[5] Public Law 87-174 (76 Stat. 653, 16 USC, 460K-460-K-4).

[6] U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, unpublished.

For projection purposes, it was assumed that the ratio of State park visits to National park visits will continue to increase in the future at approximately the same rates as in the past, giving a ratio of 15 to 1 in 1980 and 19 to 1 in the year 2000. This assumption is based on expectations that State parks will continue to serve as high intensity recreation areas, particularly as weekend recreational facilities near metropolitan areas.

Based on projected visits per 100 persons to National parks, visits to State parks are projected to be:

	1980	2000
National park visits (per 100 population)	35.72	70.76
Ratio of State park visits to National park visits	15:1	19:1
State park visits (per 100 population)	535.80	1,344.40

General trends between 1960 and 1965 in visits to State parks in the regions have been used to project the distribution of State park visits. In the Northeast and North Central Regions, the ratios of visits per 100 population, even though above the national average, have tended to move toward the national average. It has been assumed, therefore, that in 1980 and 2000 they will equal the national average. The West, however, has had increasingly higher numbers of State park visits per 100 persons than other regions of the Nation, and it is assumed that the West will continue to show above-average visits in the future. In making projections for individual States in the West, the regional average for visits to parks per 100 population was used. Differences between States are therefore the result of differences in populations, and the low, medium, and high projections of park visits are the result of the range of the population projections (table 54).

The Southern Region has not participated in the general increase of more intensive visits to State parks. With increasing population growth in the South and the resulting urbanization, the number of visits to State parks per 100 of population will rise, even though it is not expected that

Table 54. Visits to State Parks, by Region, 1965 and Projected 1980 and 2000
(in millions)

Region	1965 (actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
United States[a/]	420.2	1,249.5	1,290.6	1,355.2	3,785.2	4,118.1	4,625.5
Northeast............	121.0	287.9	297.4	312.2	860.4	935.9	1,060.3
North Central........	140.0	321.8	332.4	348.9	977.8	1,063.8	1,164.8
South................	71.6	312.8	323.1	339.2	1,084.0	1,179.3	1,336.0
West:							
Montana..............	2.0	6.2	6.4	6.8	15.0	16.3	18.5
Idaho................	2.0	6.2	6.4	6.8	15.0	16.3	18.5
Wyoming..............	.9	2.9	3.0	3.1	7.0	7.7	8.8
Colorado.............	5.5	19.3	19.9	21.0	48.1	52.3	59.4
New Mexico...........	2.9	10.3	10.6	11.2	29.6	32.1	36.5
Arizona..............	4.4	18.0	18.6	19.5	52.1	57.2	64.7
Utah.................	2.8	10.0	10.4	10.9	27.9	30.2	34.3
Nevada...............	1.2	5.1	5.3	5.6	12.4	13.5	15.6
Washington...........	8.4	27.2	28.0	29.4	66.7	72.5	82.1
Oregon...............	5.5	18.2	18.7	19.7	44.2	48.1	54.3
California...........	52.0	203.6	210.4	220.9	545.0	592.9	671.7

[a/] Excludes Alaska and Hawaii.

Source: U.S. Bureau of Outdoor Recreation, unpublished data (compiled by Department of Commerce, Bureau of Census, 1965).

State park visits in the South will match the national average by 2000.

Participation in Outdoor Recreation

The previous sections of this chapter dealt with visits to public (Federal and State) recreation lands. This section deals with total outdoor recreation participation on all land and water regardless of ownership. The growth of outdoor recreation indicates more intensive use of existing facilities as well as the need for additional facilities. These factors clearly have implications for public land policies. However, there is no proportional relationship between rising outdoor recreation participation and public land needs. Outdoor recreation activities are satisfied wherever the facilities occur, on private as well as public lands, on Federal as well as State and municipal lands. Further, a variety of activities is not mutually exclusive; two or more activities can be satisfied at one location.

Two nationwide surveys have been conducted on participation in outdoor recreational activities: The Outdoor Recreation Resources Review Commission (ORRRC) reported results of its survey in a 1960 publication, Outdoor Recreation for America [1], and the 1965 publication of the Bureau of Outdoor Recreation (BOR), Outdoor Recreation Trends [5], summarized data gathered by the Bureau of the Census. Although the activities covered were not identical in the two surveys, a total of 24 recreation activities were included, with many individual activities projected on a national basis to the year 2000.

For the purposes of this study, 22 outdoor recreation activities[8] were grouped into five categories, and participation was projected by groups of activities rather than individual activities. The ORRRC and BOR surveys covered most, but not all, activities. Newer and less popular activities, such as snowmobile riding and parachute jumping, were not listed. It is, therefore, more meaningful to project groups of activities to allow for shifts in preferences. Projections have been made for each of the regions considered in this study.

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[8] Two additional activities covered by the BOR survey and excluded from this study are bird watching and wildlife and bird photography.

(1) Passive outdoor recreation:

- Walking for pleasure
- Driving for pleasure
- Sightseeing
- Attending outdoor sports events
- Picnicking
- Nature walks
- Attending outdoor concerts and dramatic presentations

(2) Physically active recreation:

- Playing outdoor games or sports
- Bicycling
- Horseback riding

(3) Water sports:

- Swimming
- Canoeing
- Sailing
- Other boating
- Water skiing

(4) Winter sports:

- Sledding
- Snow skiing
- Ice skating

(5) Back-country recreation:

- Fishing
- Camping
- Hiking
- Hunting

The 1965 BOR survey was used as the basis for projecting participating occasions to 1980 and 2000. In addition, use was made of unpublished data gathered by the Bureau of the Census for BOR which provided: (1) the percentage of the population 12 years and over participating in each of the 22 activities, and (2) the number of participating occasions per participant. These BOR participation rates were determined from the BOR survey for the Nation, census regions, and by family income class.

Our analyses of the survey results show that there is an important relationship between participation and levels of income. For both the number of participants and the number of participating occasions per participant, participation is lowest for families with incomes under $3,000. Participation apparently rises sharply as income rises, stays relatively constant for families with incomes around $10,000, but begins to decline slightly as family incomes continue to rise. The exception to this income relationship is found in back-country recreational activities. For these activities, income changes do not correlate with participation rates. Rather, participation in back-country recreation activities is related to the degree to which the population is urbanized.

Regional Participation Occasions in 1980

The basic assumption in projecting passive, physically active, and water sports is that the average national participation in 1980 will be the same as the national family income class with the highest participation rates in 1965. This assumption reflects the expectation that the family income class with the highest recreation participation rate in 1965 is the most likely to be representative of family incomes in 1980. For each of the three groups of recreational activities, a national per capita (12 years and over) participation occasion factor was calculated from the 1965 participation rates. The factor was an average of the highest percentage of population participating and the highest rate of participating occasions for each activity in each group.

Next, the national 1965 factor was used to arrive at the 1980 per capita (12 years and over) participating occasion factor for each of the four census regions. This was accomplished by taking the 1965 regional per capita participating occasions and adjusting them for consistency with the projected national per capita participating occasion factor. Thus, the relative distribution of participation rates among the regions was retained, even though their absolute values increased.

The final step to arrive at the number of participating occasions was accomplished by multiplying each regional recreation group participating occasion factor by the low, medium, and high populations of 12 years and over in 1980. For the States in the western census region, the western regional factor was applied to each State projection of low, medium, and high population of 12 years and over. It was not possible to project recreation participation separately by regional residents and nonresidents. Projected visits to Federal and State

lands reflect the total combined visits. The participation projections are basically tied to the resident population.

The BOR survey did not provide the number of participating occasions per participant for winter sports. The projections for winter sports, therefore, are for participants, not for occasions.

Since back-country recreational activities are related to metro-urbanization (as metro-urbanization occurs, participation decreases), participation in these activities is expected to decline. The Northeast has the highest concentration of urban metropolitan population and, therefore, the lowest participation in back-country recreation. Further metropolitan growth is expected to increase relatively faster outside the Northeast. It is assumed, therefore, that regional participation rates in back-country recreation activities in the South, North Central Region, and West will tend to move toward the 1965 Northeast Region level. It was further assumed that by 1980 the spread between the Northeast and other regional participation rates will diminish by one-third.

Regional Participation Occasions in 2000

The 1980 per capita participation occasion factors were adjusted for the year 2000 in the following manner: For passive, physically active, and water sports, it was assumed that there will be no further increase in the region with the highest participation, and that due to increasing interregional homogeneity, other regions will more closely resemble the region with the highest participation. The 1980 spread between each region's participation factor and the region with the highest factor was assumed to diminish by 50 percent by 2000.

Two counteracting factors were recognized as affecting future participation in winter sports -- the trend of population migration toward the warmer southern climates, and the increased mobility of population and accessibility of winter sport recreation areas. It was assumed, therefore, that the per capita participation occasion factors for winter sports in all regions will remain constant between 1980 and 2000.

Since metropolitan growth is expected to continue beyond 1980, it was assumed that the decline in back-country recreation participation will also continue. Therefore, between 1980 and 2000 the spread between the Northeast and other regional participation rates was further reduced by one-third (table 55).

Projections of regional participation in the various groups of activities in 1980 and 2000 are shown in table 55.

Fishing and Hunting

Fishing and hunting are two of the oldest sports, as well as a means of supplementing the diet. Each State has its own licensing policy, but generally persons under 12 years of age are not required to have a fishing license, nor is a license required for salt water fishing. All States have laws governing the kinds and amounts of game that can be hunted, as well as the time hunting is permitted. Hunters are usually required to buy a hunting license or a hunting tag. It should also be noted that many persons buy licenses in more than one State.

Multiple regression equations were used in projecting the future demand for both fishing and hunting licenses for census regions of the United States. Variables used for explaining the past were recreation preferences, measured by the increases in licenses issued over time, metro-urbanization, income, leisure time, and mobility. In order to derive estimates for individual States in the West, the projected rate of license issues per 100 population for the West was applied to the population of individual States.

Fishing Licenses

About 14 million persons purchased fishing licenses in 1948, and this number steadily increased to 20.4 million in 1965, an increase of about 45 percent. There were 9.64 fishing license holders per 100 population in 1948, increasing to 10.54 in 1965. However, this rate vacillated during the 18-year period, and has declined steadily since 1958.

In projecting demand, the variables of time (as a measure of recreation preferences, education, etc.), metro-urbanization, and income were used. Income appears to have

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Table 55. Recreation Groups, Varying Levels of Participation Occasions, By Region, 1965 and Projected 1980 and 2000

(in millions of occasions)

Group and region	1965 (actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Passive recreation							
United States[a/]	6,181	9,970	10,005	10,359	13,682	14,468	15,550
Northeast	1,632	2,537	2,546	2,638	3,138	3,319	3,598
North Central	1,853	2,836	2,846	2,948	3,566	3,772	3,952
South	1,555	2,533	2,542	2,634	4,178	4,419	4,790
West:[a/]							
Montana	26	39	39	41	49	51	56
Idaho	25	39	39	41	49	51	56
Wyoming	12	18	18	19	23	24	26
Colorado	72	122	122	127	156	165	179
New Mexico	37	65	65	68	96	101	110
Arizona	58	114	115	119	170	180	195
Utah	37	64	64	66	90	95	103
Nevada	16	32	32	34	40	42	46
Washington	109	171	172	178	216	229	248
Oregon	71	115	115	120	143	151	164
California	678	1,285	1,290	1,336	1,768	1,869	2,027

Continued--

Table 55. Recreation Groups, Varying Levels of Participation Occasions, By Region, 1965 and Projected 1980 and 2000 -- Continued

(in millions of occasions)

Group and region	1965 (actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Physically active recreation							
United States[a]..........	3,388	6,354	6,375	6,644	8,557	9,051	9,718
Northeast..............	864	1,566	1,571	1,628	1,985	2,099	2,276
North Central..........	1,103	1,970	1,977	2,084	2,389	2,527	2,648
South..................	847	1,606	1,612	1,670	2,456	2,598	2,816
West:							
Montana..............	13	23	23	24	30	32	34
Idaho................	13	23	23	24	30	32	34
Wyoming..............	6	11	11	11	14	15	16
Colorado.............	36	71	72	74	96	102	110
New Mexico...........	19	38	38	40	59	63	68
Arizona..............	29	67	67	70	105	111	120
Utah.................	18	37	37	39	56	59	64
Nevada...............	8	19	19	20	25	26	28
Washington...........	55	101	101	105	133	141	153
Oregon...............	36	67	67	70	88	93	101
California...........	341	755	757	785	1,091	1,153	1,250
Water sports							
United States[a]..........	3,709	7,004	7,028	7,783	9,497	10,044	10,791
Northeast..............	1,039	1,891	1,898	1,966	2,296	2,429	2,633
North Central..........	1,071	1,918	1,924	1,994	2,494	2,637	2,763
South..................	897	1,708	1,714	1,776	2,689	2,844	3,083
West:							
Montana..............	16	28	28	29	35	37	40
Idaho................	16	28	28	29	35	37	40
Wyoming..............	7	13	13	14	17	17	19
Colorado.............	44	88	88	91	112	119	129
New Mexico...........	23	47	47	49	69	73	79
Arizona..............	36	82	83	85	123	130	141
Utah.................	22	46	46	48	65	69	74
Nevada...............	10	23	23	24	29	31	33
Washington...........	67	123	124	129	156	165	179
Oregon...............	44	83	83	86	103	109	118
California...........	417	926	929	963	1,274	1,347	1,460
Winter Sports[b]							
United States[a]..........	1,267	2,837	2,847	2,951	3,493	3,694	3,955
Northeast..............	453	1,001	1,005	1,041	1,194	1,263	1,369
North Central..........	515	1,119	1,123	1,163	1,357	1,435	1,504
South..................	122	283	284	294	353	373	405
West:							
Montana..............	4	8	8	9	10	11	12
Idaho................	4	8	8	9	10	11	12
Wyoming..............	2	4	4	4	5	5	6
Colorado.............	11	26	26	27	34	35	38
New Mexico...........	6	14	14	14	20	21	23
Arizona..............	9	24	24	25	36	38	41
Utah.................	5	13	13	14	19	20	22
Nevada...............	2	7	7	7	8	9	10
Washington...........	16	36	36	38	45	48	52
Oregon...............	11	24	24	25	30	32	35
California...........	107	270	271	281	372	393	426

Continued--

Table 55. Recreation Groups, Varying Levels of Participation Occasions, By Region, 1965 and Projected 1980 and 2000 -- Continued

(in millions of occasions)

Group and region	1965 (actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Back-country Recreation							
United States[a/]	2,005	2,249	2,256	2,341	2,549	2,697	2,899
Northeast..............	339	406	408	423	485	513	556
North Central..........	560	593	595	617	638	675	707
South..................	690	758	760	788	882	933	1,011
West:							
Montana................	9	9	9	10	9	10	11
Idaho..................	9	9	9	10	9	10	11
Wyoming................	4	4	4	5	4	5	5
Colorado...............	26	29	29	30	30	32	35
New Mexico.............	14	16	16	16	19	20	21
Arizona................	21	27	27	28	33	35	38
Utah...................	13	15	15	16	18	19	20
Nevada.................	6	8	8	8	8	8	9
Washington.............	40	41	41	43	42	44	48
Oregon.................	26	27	27	28	28	29	32
California.............	248	307	308	319	344	364	395

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a/ Excludes Alaska and Hawaii.
b/ Number of participants only.

Source: 1965 data from U.S. Bureau of Outdoor Recreation, unpublished.

an inverse relationship to fishing activity, but other factors, such as changing recreation preferences, tend to offset the effects of income increases. Fishing license demand is projected to be 13.63 per 100 population in 1980 and 18.60 by 2000.

Table 56 shows the regional breakdown of the total license holders for 1948 and 1965 and the projected demand for 1980 and 2000.

Hunting License Holders

The number of hunting license holders has also vacillated in the past 14 years, increasing from about 14 million in 1952 to a peak of almost 15 million in 1957, and declining thereafter until 1965 when there were about 14.3 million. Slight annual increases have occurred since 1960. Although the number of hunters has increased slightly since 1952, the number of license holders per 100 population has dropped steadily, from 9.31 in 1953 to 7.37 per 100 in 1965.

Metro-urbanization was considered to be the most important factor in projecting future demands for hunting licenses. As rural areas become urbanized, hunting grounds and natural habitats for wildlife are pushed farther away from the hunter. Another aspect of metro-urbanization is the lack of acquaintance with guns. Whereas not many years ago almost every young man had some kind of gun, the urban youths of today have little reason or opportunity to become familiar with guns.

The number of hunting license holders in 1965 was 7.37 per 100 population. This rate is projected to decline to 7.11 per 100 population by 1980, and to 6.73 by 2000.

Table 57 shows the regional breakdown of total hunting license holders for 1952 and 1965 and the projected demand for 1980 and 2000.

Table 56. National and Regional Fishing License Holders, 1965 and Projected 1980 and 2000
(in thousands)

Region	1965	1980			2000		
		Low	Medium	High	Low	Medium	High
United States[a/]	20,428	31,014	32,043	33,644	52,996	57,660	64,672
Northeast	2,133	2,955	3,053	3,205	4,736	5,152	5,836
North Central	7,407	9,550	9,864	10,356	15,710	17,092	18,714
South	6,344	11,152	11,519	12,092	18,941	20,608	23,346
West:[a/]	4,544	7,357	7,607	7,991	13,609	14,808	16,776
Montana	280	454	468	492	838	912	1,034
Idaho	265	427	444	466	794	863	978
Wyoming	144	233	241	253	431	469	532
Colorado	431	698	722	758	1,291	1,405	1,592
New Mexico	107	173	179	188	320	348	394
Arizona	248	402	415	436	743	809	916
Utah	236	382	395	415	706	769	871
Nevada	79	125	132	139	237	258	292
Washington	427	692	715	751	1,280	1,392	1,577
Oregon	528	854	884	929	1,579	1,718	1,946
California	1,799	2,917	3,012	3,164	5,390	5,865	6,644

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a/ Excludes Alaska and Hawaii.

Source: Bureau of Sport Fisheries and Wildlife, unpublished summaries compiled from information furnished by the State Fish and Game Departments, U.S. Department of the Interior, Fish and Wildlife Service. These licenses are for the contiguous United States.

Table 57. National and Regional Hunting License Holders, 1965 and Projected 1980 and 2000
(in thousands)

Region	1965	1980			2000		
		Low	Medium	High	Low	Medium	High
United States[a/]	14,277	15,989	16,512	17,340	18,888	20,550	23,046
Northeast	2,403	2,633	2,719	2,855	2,944	3,203	3,628
North Central	4,803	4,925	5,087	5,341	5,673	6,172	6,758
South	4,516	5,256	5,429	5,699	6,196	6,741	7,636
West:[a/]	2,555	3,175	3,277	3,445	4,075	4,434	5,024
Montana	177	220	227	239	282	307	348
Idaho	178	221	228	240	284	309	350
Wyoming	120	149	154	162	191	208	236
Colorado	281	349	361	379	448	488	553
New Mexico	82	102	105	111	131	142	161
Arizona	127	158	163	171	203	221	250
Utah	198	246	254	267	316	344	390
Nevada	52	65	67	70	83	90	102
Washington	322	400	413	434	514	559	633
Oregon	333	414	426	449	530	577	654
California	685	851	879	923	1,093	1,189	1,347

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a/ Excludes Alaska and Hawaii.

Source: Bureau of Sport Fisheries and Wildlife, unpublished summaries compiled from information furnished by the State Fish and Game Departments, U.S. Department of the Interior, Fish and Wildlife Service. These licenses are for the contiguous United States.

CHAPTER VIII

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CHAPTER IX

LAND OCCUPANCY REQUIREMENTS

This chapter presents projections of land area occupancy requirements for four major nonagricultural land uses in the years 1980 and 2000. Projections were made for the following land-use categories: urban land; rural land withdrawn for transportation and other rights-of-way uses; rural land withdrawn for second homesites; and rural land controlled by the U.S. Department of Defense (DOD) and used for military purposes.

Because of the limited quality and availability of statistical data on the occupancy uses of land, and the limited body of theoretical knowledge about interrelationships between land uses and land area occupancy, projections based on formal objective analyses were considered inappropriate. All projections in this chapter are essentially judgmental in nature, and are based on qualitative reviews of existing information on past, present, and future land occupancy requirements for the four land uses considered.

The medium projections represent the land area occupancy requirements judged most probable in the target years. High and low projections represent judgments as to the plausible range of possible deviations from medium projections. A summary of projections for the four land-use categories is presented in table 58 below.

Urban Land

Urban land is defined in this report as the land area within which the resident population would be classified as urban because of its size or density, under the definition of urban used by the 1960 *U.S. Census of Population* [7, Part 1, *U.S. Summary*, pp. xviii, xix, and xxvi]. The remainder of the total land area is defined as rural land. In 1960, urban land comprised 23.7 million acres (or 1.25 percent) of the 1,902 million acres of land in the 48 States.1/

1/ Unpublished estimates by the U.S. Department of Agriculture, Economic Research Service, Land Resources Branch. This

Table 58. Summary of Land Occupancy Requirements,[a] Base Year and Projected 1980 and 2000

(in thousands of acres)

Category	Base Year	1980			2000		
		Low	Medium	High	Low	Medium	High
Urban land.........	23,656[b]	33,545	34,689	36,477	44,495	48,727	55,410
Rural land:							
Transportation...	25,693[c]	25,690	26,420	27,740	25,690	27,500	28,860
Utility rights-of-way[d]........							
Electric overhead lines[e]...	3,161	7,215	7,589	7,835	9,242	9,803	10,172
Gas pipeline[f].	658	1,027	1,089	1,135	1,211	1,304	1,373
Petroleum pipeline[g]........	410	519	577	622	823	988	1,258
Second homes.....	3,290[b]	4,668	4,770	4,923	5,395	5,721	6,225
Dept. of Defense.	22,749[h]	20,474	22,749	24,024	20,474	22,749	24,024

[a] Excluding Alaska and Hawaii.
[b] 1960
[c] 1964
[d] Because many utilities share common rights-of-way, the aggregates of all utility requirements are not projections of total utility rights-of-way land requirements in 1980 and 2000.
[e] 1965 (55,000 volts and above).
[f] 1965 (transmission).
[g] 1966 (Interstate).
[h] 1966.

The area encompassed by urban land consists primarily of land which is in use for such purposes as housing, industry, and transportation. In addition, urban land includes a substantial area which is vacant or which is used for such nonurban purposes as farmland and woodland. The proximity of land already used for urban purposes to such woodland and farmland effectively withdraws it from potential long-term use for nonurban purposes. For this reason, the term urban land, as used in this report, describes the total land withdrawn by urbanization from potential long-term nonurban use, even though part of this land is not currently being used for urban purposes.

Historical time series describing the amount of urban land, as defined here, in each region and State are not available. It was therefore not possible to trace the exact historical relationships between urban land area, population, and income in the geographic areas for which the demand for urban land was projected. It was possible, however, to recognize several general relationships which determine the demand for urban land.

First, the demand for urban land is related to the size of the urban population. As the urban population has grown, the amount of urban land has also grown. Second, the demand for urban land is also related to the population size of urban places. The smallest urban places in terms of population contain the greatest amounts of urban land per person, and have the lowest population densities. In contrast, the largest urban places in terms of population contain the smallest amounts of urban land per person and have the highest population densities.

Third, the very high population densities of most of the Nation's largest urban places appear to reflect their

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definition of urban land excludes certain categories of land which might be considered urban if different definitions were used. In 1959, approximately 3.6 million acres of land in the 48 contiguous States were occupied by towns and villages with populations over 1,000 persons but under 2,500 which were defined as urban by the USDA, but are defined as rural in in this study. In addition, the USDA has estimated that several million additional acres of land are occupied by towns and villages with fewer than 1,000 persons, which both USDA and this study define as rural land [c.f., 8, table 20, p. 42].

maturation pior to 1920, when the widespread use of the automobile and the development of low-density suburbs accessible primarily by automobile began. Since 1920, population densities in the Nation's older metropolitan areas have declined. At the same time, those large urban areas which have developed since 1920 have done so at a substantially lower population density than the Nation's older cities.

Differences in regional urban population densities in 1960 reflect the impact of these factors. In the Northeast Region, the oldest and most urbanized, the density of urban population is substantially higher than the national average. In contrast, the South exhibits a substantially lower density of urban population than the rest of the Nation, reflecting the recent nature of urbanization and the large number of small urban places in the South.

Variations from the national average density of urban population in the 11 western States result from two causes. In many of these States, the urban population historically has been concentrated in one, or at least a small number, of old and relatively dense cities. In those western States with relatively small urban populations, the presence or absence of such historic urban concentrations causes major differences in urban population densities. In the western States with relatively large urban populations -- California, Washington, Colorado, and Oregon -- variations from the national average result from the same variations in age of urban areas and population size distribution of urban places that affect other regional urban population densities.

At present, the average density of urban population in the 48 States is approximately five persons per acre. In projecting the demand for urban land in 1980 and 2000, it was assumed that overall regional and State population densities will tend to approach this national average, and that incremental changes in urban land by region and State between 1960 and the target years will occur at the rate of 1 additional acre of urban land per five additional urban residents. This assumption is based on the following reasoning:

(1) Densities in the largest urban places (measured in terms of population size) are decreasing towards the 1960 national average.

(2) Densities in the smallest urban places will increase towards the 1960 national average as these places increase in population size.

Projections of the demand for urban land in 1980 and 2000 are presented in table 59.

Rural Land Withdrawn for Transportation and Other Rights-of-Way

Rural land withdrawn for transportation uses is defined in this report as the area of rural land withdrawn by highways, railroads, and airports from primary use for other purposes. Measurements of this area of land in each region and State are available for the years 1959 and 1964. In 1964, rural land withdrawn for transportation uses comprised 25.7 million acres (or 1.35 percent) of the 1,902 million acres acres of land in the 48 States.[2]

Measurements of land areas used for rights-of-way for electrical transmission lines, natural gas pipelines, and petroleum pipelines are not available. The existing statistical information relating to rights-of-way used by these utility carriers is generally expressed in terms of line mileage. Further, because of the suitability of utility rights-of-way for multiple use, it is extremely difficult to determine the amount of land withdrawn for the exclusive use of any given utility.

Given these difficulties, no attempt was made to deal explicitly with land withdrawals for utility rights-of-way. Rather, estimates were made of current and future land requirements for each such utility, ignoring the possibility of the various utilities sharing common rights-of-way. Also, because the projections of urban land requirements include

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[2] Data on rural land areas withdrawn for transportation uses are based on unpublished estimates, U.S. Department of Agriculture, Economic Research Service, Land Resources Branch. These estimates slightly understate rural land uses withdrawn for transportation uses because of exclusion of some land defined as urban by USDA, but as rural in this report.

Table 59. Urban Land, 1960 and Projected 1980 and 2000
(in thousands of acres)

Region	1960 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Northeast..........	4,815	6,501	6,795	7,249	8,463	9,413	10,977
North Central......	6,553	8,527	8,825	9,291	11,225	12,259	13,961
South..............	8,233	11,759	12,087	12,599	15,249	16,649	18,623
West: a/	4,055	6,758	6,982	7,338	9,558	10,404	11,849
Montana..........	53	77	81	85	113	125	143
Idaho............	74	99	103	107	132	142	159
Wyoming..........	36	47	49	51	68	73	83
Colorado.........	202	353	365	387	495	543	652
New Mexico.......	171	258	266	276	388	418	468
Arizona..........	288	480	494	514	688	742	826
Utah.............	196	269	275	287	365	391	435
Nevada...........	46	116	118	124	150	164	184
Washington.......	427	550	568	594	736	797	896
Oregon...........	238	342	352	368	460	498	562
California.......	2,324	4,167	4,311	4,545	5,963	6,511	7,441
United States a/....	23,656	33,545	34,689	36,477	44,495	48,727	55,410

a/ Excluding Alaska and Hawaii.

Source: 1960 data from unpublished estimates by USDA, Economic Research Service, Land Resources Branch.

the requirements for utility distribution lines, separate projections were made only for long-distance transmission lines.

In 1965, there were approximately 260,800 circuit miles of overhead electric transmission lines (55,000 volts or above) in the United States. In estimating electric line rights-of-way in 1965, it was assumed that each circuit mile requires approximately 100 feet of right-of-way width, on the average, or about 12 acres of land.

The land requirements for electric line rights-of-way in the future are assumed to increase at the same rate as electricity generation, by region, between 1965 and 1980. Between 1980 and 2000, however, it is assumed that the extensive size of the system will permit an increase in the utilization of rights-of-way. Thus, the rate of increase in land requirements are assumed to be only 50 percent of the rate of increase in electricity generation. The medium projections are, therefore, that 7.6 million acres will be required for electricity transmission in 1980, with 9.8 million required in 2000, compared with 3.1 million in 1965 (table 60).

The same general procedure was used in projecting the land requirements for gas and petroleum pipelines. It was assumed that each mile of line requires 25 feet of right-of-way, or about 3 acres of land. Estimates of land requirements were made for 1965 and projected to increase at the same rate as gas and petroleum consumption between 1965 and 1980. Again, it was assumed that more efficient use of rights-of-way between 1980 and 2000 would result in a rate of increase 50 percent of the projected increase in gas and oil consumption.

The medium projections of gas pipeline land requirements are 1.1 million acres in 1980 and 1.3 million in 2000, compared with 217,000 acres in 1965 (table 61).

Petroleum pipelines requirements were estimates to be 410,000 acres in 1966. The medium projections are 577,000 acres in 1980 and 988,000 in 2000 (table 62).

Rural highway rights-of-way make up the bulk of rural land withdrawn for transportation uses. In 1959, rural highways occupied 20.4 million acres of land in the 48 States,

Table 60. Overhead Electric Lines (55,000 volts and above)
Right of Way Requirements, Estimated 1965 and
Projected 1980 and 2000

(thousands of acres, except where indicated)

Region	1965		1980			2000		
	Actual circuit miles	(Estimated) b/ acreage	Low	Medium	High	Low	Medium	High
United States a/..	260.8	3,161	7,215	7,589	7,835	9,242	9,803	10,172
Northeast.....	32.1	389	988	1,039	1,071	1,288	1,364	1,412
North Central.	78.5	952	2,155	2,270	2,340	2,756	2,929	3,034
South.........	87.4	1,059	2,280	2,399	2,476	2,890	3,069	3,184
West: a/	62.8	761	1,792	1,881	1,948	2,308	2,441	2,542
Montana.....	4.7	57	74	78	80	82	88	91
Idaho.......	4.9	59	109	114	119	134	141	149
Wyoming.....	3.1	38	51	54	55	57	62	63
Colorado....	3.1	38	112	118	122	149	158	164
New Mexico..	2.1	25	38	40	41	44	47	49
Arizona.....	4.2	51	136	143	147	178	189	195
Utah........	2.9	35	111	116	120	149	156	162
Nevada......	2.1	25	76	80	83	101	107	112
Washington..	7.8	95	114	120	124	123	132	138
Oregon......	5.2	63	133	139	144	168	177	184
California..	21.9	265	805	847	875	1,075	1,138	1,180

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a/ Includes Alaska and Hawaii.
b/ Lines of 50,000 volts and above apportioned to regions on the basis of regional percentage of total U.S. line miles; acreage requirement computed on basis of 100 ft. average right-of-way width per circuit mile.

Source: 1965 circuit miles from [3, p.56].

Table 61. Gas Transmission Pipeline Right of Way Requirements,
Estimated 1965 and Projected 1980 and 2000

(thousands of acres, except where indicated)

Region	1965		1980			2000		
	(Actual) Pipeline miles	(Estimated) b/ acreage	Low	Medium	High	Low	Medium	High
United States a/..	217	658	1,027	1,089	1,135	1,211	1,304	1,373
Northeast......	20	62	96	101	106	113	121	128
North Central..	61	183	286	304	317	337	364	384
South.........	105	319	498	528	550	587	632	665
West: a/	31	94	147	156	162	174	187	196
Montana......	3	8	12	13	14	14	15	17
Idaho........	1	3	5	5	6	6	6	7
Wyoming......	3	8	12	13	14	14	15	17
Colorado.....	4	11	17	19	19	20	23	23
New Mexico...	5	14	23	24	25	27	29	30
Arizona......	4	13	21	22	23	25	26	28
Utah.........	1	2	4	4	4	5	5	5
Nevada.......	1	3	4	4	4	5	5	5
Washington...	1	4	6	7	7	7	8	8
Oregon.......	1	4	5	5	6	6	6	7
California...	7	22	35	37	39	41	44	47

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a/ Includes Alaska and Hawaii.
b/ Pipelines have been apportioned to regions on the basis of regional percentage of total U.S. pipelines; acreage requirements computed on 25 ft. average right-of-way width per mile.

Source: 1965 pipeline miles from [1, p. 122].

Table 62. Interstate Petroleum Pipeline Rights-of-Way Requirements, Estimated 1966 and Projected 1980 and 2000

(thousands of acres, except where noted)

Region	1966		1980			2000		
	Pipeline mileage	(Estimated) acreage[b]	Low	Medium	High	Low	Medium	High
United States[a] ..	135	410	519	577	662	823	988	1,258
Northeast......	10	29	36	40	46	57	69	88
North Central..	40	122	155	172	197	245	294	375
South.........	69	210	266	296	340	422	507	645
West:[a]	16	49	62	69	79	99	118	150
Montana......	2	6	7	8	9	12	14	18
Idaho........	1	2	2	2	3	3	4	5
Wyoming......	4	12	16	17	20	25	30	38
Colorado.....	1	4	5	5	6	7	9	11
New Mexico...	4	13	17	19	22	27	33	41
Arizona......	1	3	4	4	5	6	7	9
Utah.........	1	2	3	3	4	5	6	8
Nevada.......	0	1	1	1	1	2	2	3
Washington...	1	2	2	2	3	3	4	5
Oregon.......	0	1	1	1	1	2	2	3
California...	1	3	4	5	5	7	8	10

[a] Includes Alaska and Hawaii.
[b] See corresponding footnote, table 60.

Source: 1966 pipline miles from [2, p. 122].

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rural railroads occupied 3.4 million acres of land and rural airports occupied 1.4 million acres of land [8, p.10]. Most of the land occupied by rural highways is used for locally controlled roads which serve primarily local purposes. In 1964, locally controlled rural highways included 2.3 million miles (or 74 percent) of the total 3.1 million miles of rural highway in the 48 States [13, pp. 123-4], or about 14 million acres of rural land.[3]

The demand for rural land withdrawn for transportation uses is related to several factors. First, the size and geographic dispersion of the rural population has determined the mileage of locally controlled rural highways in the different regions and States. The lightly traveled nature of this highway mileage has required relatively small areas of land per mile for rights-of-way, but in total has required a very large area of rural land. The area of rural land required for such rights-of-way does not appear likely to increase substantially in the future.

Second, the distance between urban centers has determined the mileage of rural State primary and secondary highways, as well as the mileage of railroads. The level of traffic has determined the area of land required for State primary and secondary highway rights-of-way, but main-line railroads have generally occupied standard rights-of-way with a wide range of potential traffic capacity. In recent years, the mileage and rights-of-way area of rural main-line railroads has declined substantially, and most rural railroads carry a substantially lower level of traffic than their design capacity.

The area of rural land devoted to airport use appears likely to remain relatively constant. Many of the airports currently classified as rural are relatively close to urban areas. While the total area of all airports is likely to increase in the future, the area of airports not located in urban areas is likely to remain constant because of the expansion of urban areas.

In contrast, the right-of-way requirements of rural State primary highway networks have increased substantially in recent years, as traffic volumes have increased, in response to growth in population and economic activity. However, the decreasing area of rural land used for railroad rights-of-way and the expansion of existing highway rights-of-way has permitted rural highways to increase their capacity substantially without comparable increases in the total area of rural land withdrawn for transportation uses.

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[3] Estimate of rural land occupied by locally controlled rural highways by Robert R. Nathan Associates, Inc., based on right-of-way averages reported in [9, p.7].

The development of the Interstate Highway System has required particularly large rights-of-way per mile, and has made a major impact on rural land withdrawn for transportation, particularly in the 11 western States. In total, however, the completed 41,000-mile Interstate Highway System will require only 1.5 million acres of new right-of-way, both rural and urban, or less than one-tenth of 1 percent of the 1,902 million acres of land in the 48 States [9, p.75].

Changes in regional and State areas of rural land withdrawn for transportation uses between 1959 and 1964 vary widely. These changes do not appear to be directly related to regional or State changes in population or income over the same period. Instead, regional and State variations appear to result from differences in geographic size, distribution of population, and extent of existing rural transportation facilities. In the case of the 11 western States, variations also have resulted from the location of particular States in relation to the Interstate Highway System and the Nation as a whole. In general, increases in rural land withdrawn for transportation uses have resulted primarily from increases in State primary highway and Interstate Highway rights-of-way.

In projecting the most probable (medium) demand for rural land withdrawn for transportation purposes in 1980, it was assumed that increases in rural rights-of-way necessary to complete the Interstate Highway System as presently planned would roughly approximate incremental changes in the rural land withdrawn for transporation uses by region and State. The projection for 1980 represents an annual growth rate of approximately 0.2 percent for the Nation as a whole between 1964 and 1980.

The medium projection for rural land withdrawn for transportation uses in 2000 was based on the 1980 medium projections and assumed an annual growth rate of 0.2 percent between 1980 and 2000 for each region and State. Low projections for both target years are equivalent to 1964 acreages

of rural land withdrawn for transportation uses. High projections for the target years represent 105 percent of medium projections for the same years. Projections of rural land withdrawn for transportation uses in the years 1980 and 2000 are presented in table 63.

Rural Land Withdrawn for Second Homesites

Rural land withdrawn for second homesites is defined in this report as the area of rural land withdrawn by second homes from primary use for other purposes. This definition is intended to include only the rural land area which is primarily used by second-home owners for recreation purposes and to exclude agricultural and forest land surrounding second homesites which is not primarily used for recreation purposes, although legally owned by the second-home owner. The number of second homes was estimated using information presented in the 1950 and 1960 Censuses of Housing.[4] Measurements of rural land withdrawn for second homesites are not available for the regions and States of the contiguous United States or for the Nation as a whole. We estimate that the area of rural land withdrawn by the average second home was 2 acres as of 1960, and that the total area of rural land withdrawn by second homesites comprised approximately 3.3 million acres (or 0.17 percent) of the 1,902 million acres of land in the 48 States.

Between 1950 and 1960, the total number of second homes (both urban and rural) increased substantially throughout the 48 States, both absolutely and in proportion to total population. In the aggregate, these changes are related to increases in population, personal income, and leisure time. Measured in proportion to total population, however, the number of second homes per 1,000 persons varied widely by region and State in 1960, the result of the historical role of some regions and States as vacation areas for adjoining States, variations in personal income, and variations in the accessibility of outdoor recreation facilities and opportunities to the urban population.

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[4] The number of second homes in 1950 was assumed to be equivalent to the number of nonresident dwelling units plus the number of seasonal dwelling units reported in [5, table 17]. The number of second homes in 1960 was assumed to be equivalent to the number of vacant housing units held for occasional use, plus the number of seasonal housing units [6, table 3].

Table 63. Rural Land Withdrawn For Transportation Uses, 1964 and Projected 1980 and 2000

(in thousands of acres)

Region	1964 (Estimated)	1980 Low	1980 Medium	1980 High	2000 Low	2000 Medium	2000 High
Northeast..........	1,973	1,970	2,020	2,120	1,970	2,100	2,200
North Central......	10,593	10,590	10,720	11,260	10,590	11,160	11,720
South..............	7,460	7,460	7,690	8,070	7,460	8,000	8,400
West: a/	5,667	5,670	5,990	6,290	5,670	6,240	6,540
Montana..........	728	730	760	810	730	790	830
Idaho............	284	280	300	320	280	310	330
Wyoming..........	647	650	660	690	650	690	720
Colorado.........	672	670	690	720	670	720	760
New Mexico.......	402	400	430	450	400	450	470
Arizona..........	296	300	330	350	300	340	360
Utah.............	252	250	270	280	250	280	290
Nevada...........	450	450	460	480	450	480	500
Washington.......	332	330	450	470	330	470	490
Oregon...........	415	420	420	440	420	440	460
California.......	1,189	1,190	1,220	1,280	1,190	1,270	1,330
United States a/....	25,693	25,690	26,420	27,740	25,690	27,500	28,860

a/ Excluding Alaska and Hawaii.

Source: 1964 data from unpublished estimates by USDA, Economic Research Service, Land Resources Branch.

The Northeast exhibits a high proportion of second homes in relation to total population because of its historical role as a vacation area, high personal incomes, and the relative inaccessibility of outdoor recreation facilities and opportunities to its highly urbanized population. In contrast, the South exhibits a low proportion of second homes because of low personal incomes and the relatively high accessibility of outdoor recreation facilities and opportunities to its less urbanized population.

To project the total number of rural and urban second homes for the years 1980 and 2000, the growth rates during the period 1950-60 in total second homes were examined and a base projection of 15 second homes per 1,000 total population in the target years was made. The base projection was adjusted by region and State, using an index of second homes per 1,000 population in 1960 by region and State in relation to the national average, to reflect the roles of some regions and States as vacation areas for adjoining States. Regions and States falling below the national average in 1960 were assumed to reach the base projection by 1980 and 2000. Adjusted State and regional projections were then applied to 1980 and 2000 projections of total population to determine the total number of second homes.

To project the number of rural second homes for the target years, the ratio of rural to total second homes in 1960 was examined by region and State and for the 48 States as a whole. In 1960, this ratio was 81 percent for the 48 States, and regional and State variations were generally minor. In view of the large increases in total second homes projected for all regions and States, projections of separate rural-to-total second-home ratios for each region and State would not be meaningful. For this reason, it was assumed that 80 percent of the total second homes in each region and State in the target years would be located in rural areas, based on a rounding of the 1960 ratio.

Based on current trends in the development of planned rural second-home communities, it is estimated that incremental changes in the number of rural second homes between 1960 and the target years will withdraw an average of 1 acre of rural land per rural second home. Projections of the rural land area withdrawn for second homesites in 1980 and 2000 are presented in table 64.

Table 64. Rural Land Withdrawn for Second Homes, 1960 and Projected 1980 and 2000

(in thousands of acres)

Region	1960 (Estimated)	1980			2000		
		Low	Medium	High	Low	Medium	High
Northeast	1,100	1,452	1,482	1,529	1,625	1,720	1,875
North Central	980	1,211	1,235	1,272	1,363	1,440	1,530
South	723	1,214	1,242	1,286	1,424	1,517	1,671
West:[a]	487	791	811	836	983	1,044	1,149
Montana	25	30	30	30	34	35	38
Idaho	27	32	33	34	37	39	42
Wyoming	12	13	14	14	16	16	18
Colorado	51	68	70	72	80	84	92
New Mexico	16	23	24	25	30	33	36
Arizona	24	44	46	47	60	65	71
Utah	9	20	20	21	27	28	31
Nevada	4	10	10	10	12	12	13
Washington	78	93	95	97	107	113	123
Oregon	41	54	55	56	62	65	71
California	200	404	414	430	518	554	614
United States[a]	3,290	4,668	4,770	4,923	5,395	5,721	6,225

[a] Excluding Alaska and Hawaii.

Source: Estimations and projections by Robert R. Nathan Associates, Inc.

Rural Land Controlled By the U.S. Department of Defense and Used for Military Purposes

Rural land controlled by the U.S. Department of Defense (DOD) and used for military purposes consists of rural land which is

> ...(1) owned (acquired through purchase, condemnation, donation or transfer); (2) leased; (3) public domain (withdrawn permanently or temporarily by the military departments); (4) temporary use (acquired through license or permit, temporary public land order, temporary executive or territorial order); (5) easements (utility, clearance, etc.)...[11, p.15].

Acreages of total land controlled by the DOD and used for military purposes by region and State as of June 30, 1966, were obtained from the Directorate for Real Property Management, Office of the Assistant Secretary of Defense for Installations and Logistics [11]. Estimates of rural land controlled by the DOD as of June 30, 1966, and used for military purposes were based on data presented in the Federal Real and Personal Property Inventory Report as of June 30, 1966 [14, table 2].

Based on information received from the Directorate for Real Property Management, total land areas controlled by the DOD and used for military purposes in 1980 and 2000 are not expected to vary substantially from present land areas in this category. Medium projections of rural land area in 1980 and 2000 are, therefore, identical to current estimates. High and low projections for 1980 and 2000 are, respectively, 10 percent higher and 10 percent lower than medium projections. Projections of the rural land area controlled by the DOD and used for military purposes in 1980 and 2000 are presented in table 65.

Table 65. Rural Land Controlled by the U.S. Department of Defense and Used for Military Purposes, 1966 and Projected 1980 and 2000

(in thousands of acres)

Region	1966 (Estimated)	1980			2000		
		Low	Medium	High	Low	Medium	High
United States[a/].	22,749	20,474	22,749	24,024	20,474	22,749	24,024
Northeast.....	386	347	386	425	347	386	425
North Central.	1,130	1,017	1,130	1,243	1,017	1,130	1,243
South.........	3,606	3,245	3,606	3,967	3,245	3,606	3,967
West:[a/]	17,627	15,865	17,627	18,389	15,865	17,627	18,389
Montana.....	40	36	40	44	36	40	44
Idaho.......	129	116	129	142	116	129	142
Wyoming.....	41	37	41	45	37	41	45
Colorado....	341	307	341	375	307	341	375
New Mexico..	3,921	3,529	3,921	4,313	3,529	3,921	4,313
Arizona.....	3,694	3,325	3,694	4,063	3,325	3,694	4,063
Utah........	2,275	2,048	2,275	2,502	2,048	2,275	2,502
Nevada......	3,169	2,852	3,169	3,486	2,852	3,169	3,486
Washington..	377	339	377	415	339	377	415
Oregon......	3, 71	64	71	78	64	71	78
California..	3,569	3,212	3,569	3,926	3,212	3,569	3,926

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a/ Excludes Alaska and Hawaii.

Source: Estimated 1966 data by Robert R. Nathan Associates, Inc., based on [11, and 14, table 2].

CHAPTER IX

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CHAPTER X

WATER USE

In this chapter, projections of the requirements for water in 1980 and 2000 in each of the regions considered in this study are presented. Because most water-use data is reported by drainage areas, it was necessary to rely exclusively on data provided by the U.S. Geological Survey (USGS), the only agency reporting water use in all categories by States [3].

The USGS has made water-use surveys at 5-year intervals since 1945. Because of attempts to make each new survey more complete and accurate than previous surveys, however, it proved impossible to reconcile data in the latest survey with previously collected data in constructing meaningful time series. For this reason, the projections in this chapter are based on cross-section analyses which incorporate data from the 1960 survey.

Projections have been made for the water requirements for public supplies, self-supplied industry, and irrigation. Water requirements for public supplies are defined as the total requirements for water for municipal, domestic, and commercial use, and the proportion of industrial water supplied by public water systems. Self-supplied industrial wate water is defined as all industrial water not supplied by public supplies. Irrigation requirements are based on projections of irrigated acreage in each of the regions. Because rural domestic water requirements represent less than 2 percent of water requirements in the United States, excluding waterpower, no projections were made for this category of water use.

Multiple regression equations were developed to explain and describe the use of industrial water provided by public supplies. Estimating equations were also used to determine the consumption of water from public supplies. For domestic and municipal water, self-supplied industrial water, and irrigation, projected water requirements were based on relationships determined by the USGS surveys.

In 1960, almost 266 billion gallons per day were withdrawn from streams and ground water supplies for municipal, domestic, industrial, and irrigation use. The medium projections indicate that by 1980 requirements will increase to 441.6 billion gallons, or more than 60 percent. The medium projection for 2000 is 630.8 billion gallons, representing an increase of more than 150 percent during the 40-year period (table 66).

Water Requirements for Public Supplies

Water used for public supplies includes all water pumped into public water supply systems. This water is used for municipal purposes, such as firefighting, street flushing, and public uses; for domestic purposes, such as bathing, washing, and lawn irrigation; and for commercial and industrial uses. It should be noted, however, that only a small percentage of water for industrial uses is provided by public supplies.

In projecting the water requirements for public supplies in 1980 and 2000, projections were made of the population served by public water systems, total water withdrawn, water delivered for municipal and domestic uses, water delivered for commercial and industrial uses, the consumption of water (by evaporation or incorporation in products, animal tissue, vegetative growth, etc.), and water discharged to be returned to streams and ground water storage areas.

Populations Served by Public Water Systems

The population served by water from public supplies is somewhat larger than the urban population discussed in Chapter II. The reason for this difference is that small communities with populations of less than 2,500 are not included in the Bureau of the Census definition of an urban place [2]. Many of these small communities, nevertheless, have public water systems.

In projecting the population which will be served by public water supplies in 1980 and 2000, it was assumed that the relationship of this segment of the total population to the urban population, as defined by the Bureau of the Census, would remain relatively constant. It was also assumed that

Table 66. Withdrawals of Municipal, Industrial, and Irrigation Water Requirements in the United States,[a] 1960 and Projected 1980 and 2000

(Million gallons per day)

Water use	1960 (actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Water for public supplies..	20,508	33,484	34,837	36,143	45,593	50,330	55,624
Municipal and domestic...	13,926	20,943	21,632	22,715	27,070	29,454	33,122
Industrial..............	6,582	12,541	13,205	13,428	18,523	20,876	22,502
Self-supplied industrial...	139,252	262,361	276,365	281,050	394,737	445,208	480,183
Irrigation................	106,046	119,470	130,400	134,030	123,890	135,270	138,960
Total..................	265,806	415,315	441,602	451,228	564,220	630,808	674,767

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a/ Excludes Alaska and Hawaii.

Source: 1960 data from [3].

the extension of service to nonurban areas will match the growth rate of urban populations. The projections of populations to be served by public water supplies are shown in table 67.

Water Withdrawals for Public Supplies

In 1960, total water withdrawals for public supplies in the United States amounted to almost 21 billion gallons per day. According to the medium projections, the requirements for water for public supplies will increase to 34.8 billion gallons per day by 1980 and 50.3 billion gallons per day by 2000 (table 68).

Municipal and Domestic Water Requirements

The amounts of water withdrawn for municipal and domestic uses are small, relative to water withdrawn for other purposes. In 1960, municipal and domestic uses of water accounted for only slightly more than 5 percent of all water withdrawals (table 66).

An analysis of the available data indicates that municipal and domestic uses of water will be determined by two major factors. As incomes increase there will be a tendency for the per capita use of water to increase. More swimming pools, automatic appliances, and air conditioners will tend to increase per capita use. On the other hand, increasing densities of urban populations, resulting in a greater number of apartments and other multifamily dwellings, can be expected to restrict per capita consumption. The impact of population density on regional water use is apparent when the per capita use in the densly populated Northeast, North Central, and South are compared with the West (table 69).

Because it is difficult to determine exactly how these factors will weigh in the future, the projections of municipal and domestic water use are based on the assumption that the positive and negative factors which could cause changes in per capita water use will tend to cancel out. Thus, the per capita use noted in 1960 was projected to 1980 and 2000 for each region analyzed. The range of total water-use projections has been determined, therefore, by the range of the projections of population served by public water systems.

Table 67. Population Served by Public Water Supplies, 1960 and Projected 1980 and 2000

(in thousands)

Region	1960 (actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
United States[a/]	133,894	198,296	204,839	215,051	253,302	275,599	309,516
Northeast..........	38,537	46,476	48,007	50,403	56,430	61,385	69,541
North Central......	36,156	51,948	53,660	56,333	65,072	70,798	77,517
South..............	36,769	63,100	65,178	68,421	80,941	88,065	99,762
West:[a/]...........	22,432	36,772	37,994	39,894	50,859	55,351	62,696
Montana...........	452	694	721	757	882	956	1,084
Idaho.............	449	700	727	764	884	958	1,087
Wyoming...........	217	319	328	344	412	449	513
Colorado..........	1,500	2,155	2,227	2,337	2,858	3,122	3,528
New Mexico........	661	1,171	1,207	1,271	1,799	1,951	2,218
Arizona...........	980	2,041	2,114	2,215	3,088	3,385	3,831
Utah..............	732	1,097	1,133	1,194	1,599	1,734	1,968
Nevada............	228	581	599	636	749	816	920
Washington........	2,260	2,892	2,986	3,132	3,800	4,131	4,675
Oregon............	1,380	1,932	1,992	2,094	2,506	2,728	3,084
California........	13,573	23,190	23,960	25,150	32,282	35,121	39,788

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a/ Excludes Alaska and Hawaii.

Source: 1960 data from [3].

Table 68. Water Withdrawn for Public Supplies, 1960 and Projected 1980 and 2000

(Million gallons per day)

Region	1960 (actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
United States[a].....	20,508	33,484	34,837	36,143	45,593	50,330	55,624
Northeast.........	5,180	7,176	7,480	7,748	9,409	10,416	11,520
North Central.....	5,438	8,363	8,715	9,026	11,216	12,445	13,537
South.............	4,903	8,743	9,080	9,431	12,141	13,398	14,885
West:[a]..........	4,987	9,202	9,562	9,938	12,827	14,071	15,682
Montana.........	113	189	197	205	247	270	302
Idaho...........	118	232	245	252	312	345	380
Wyoming.........	58	91	94	98	120	131	148
Colorado........	298	550	574	595	775	855	947
New Mexico......	108	201	208	217	309	336	379
Arizona.........	151	346	361	376	534	590	656
Utah............	222	348	360	378	511	556	628
Nevada..........	79	222	230	242	309	340	377
Washington......	770	1,376	1,420	1,461	1,818	2,007	2,194
Oregon..........	390	655	684	709	829	913	1,011
California......	2,680	4,992	5,189	5,405	7,063	7,728	8,660

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a/ Excludes Alaska and Hawaii.

Source: 1960 data from [3].

Table 69. Municipal and Domestic Requirements for Water from Public Supplies, 1960 and Projected 1980 and 2000

(millions of gallons per day, except where noted)

Region	1960		1980			2000		
	(Actual)	per capita[a]	Low	Medium	High	Low	Medium	High
United States[b].	13,926	104	20,943	21,632	22,715	27,070	29,454	33,122
Northeast.....	3,352	87	4,043	4,176	4,385	4,909	5,340	6,050
North Central.	3,248	90	4,675	4,829	5,070	5,856	6,372	6,976
South.........	3,383	92	5,805	5,996	6,295	7,447	8,102	9,178
West[b]........	3,943	176	6,420	6,631	6,965	8,858	9,640	10,918
Montana.....	94	208	144	150	157	183	199	225
Idaho.......	62	138	97	100	105	122	132	150
Wyoming.....	46	212	68	70	73	87	95	109
Colorado....	220	147	317	327	344	420	459	519
New Mexico..	96	145	170	175	184	261	283	322
Arizona.....	130	133	271	281	295	411	450	508
Utah........	210	287	315	325	343	459	498	565
Nevada......	65	285	166	171	181	213	233	262
Washington..	460	204	590	609	639	775	843	954
Oregon......	260	188	363	374	394	471	513	580
California..	2,300	169	3,919	4,049	4,250	5,456	5,935	6,724

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a/ For population served, gallons per day.
b/ Excludes Alaska and Hawaii.

Source: 1960 data from [3].

In 1960, according to the USGS survey, approximately 13.9 billion gallons of water were used for municipal and domestic purposes each day. Further, the use of water for these purposes was relatively evenly divided among the major census regions of the Nation. The low per capita use of the eastern region was offset by large populations, whereas the relatively small population of the West offset high per capita use (table 69).

By 1980, increased incomes and the build-up of population in the South and West will result in pronounced regional differentials in municipal and domestic water use. These differentials will become more substantial by 2000. In 2000, the South and the West will require almost twice as much water for municipal and domestic purposes as the Northeast and North Central Regions (table 69).

Industrial and Commercial Water from Public Supplies

In 1960, approximately 5 percent of total industrial water was provided by public supplies. The regional projections of industrial water provided by public supplies are based on estimating equations determined by regression analysis. Because no time series were available, a cross-section analysis of regions was made for 1960. The analysis indicated that three factors -- the number of urban places in each region, manufacturing output, and the ratio of regional manufacturing to all nonagricultural economic activity -- explained almost 100 percent of the regional variations in the industrial and commercial use of water from public supplies.

In regions with large numbers of communities with sizable populations and high manufacturing output, in both absolute and relative terms, industry tends to use relatively large amounts of water from public water systems. This can be attributed to the diversification of industry in these urbanized regions which results in a relatively larger number of industries, particularly service industries, that use small amounts of water. Such industries often find that it is more economical to purchase water from public systems than to supply their own needs. A second factor is that in regions characterized by large numbers of sizable communities, public water supplies are more likely to be designed to provide water for industrial uses.

For the contiguous regions of the Nation, the medium projections of industrial water to be supplied by public water systems are 13.2 billion gallons per day in 1980 and 20.9 billion gallons per day in 2000 (table 70).

Consumption of Water from Public Supplies

Most of the water used by industry and municipalities is eventually returned to the watershed supply. Thus, depending on how it has been altered as a result of use, it can be used again, perhaps several times. The USGS estimated that 3.5 billion gallons per day, or about 17 percent of the water withdrawn for municipal and domestic uses in 1960, was consumed [3, p.3]. Because industrial use results in greater amounts of water consumption than municipal and domestic use, regions which have public water systems that provide large supplies of water to industry, relative to the amounts supplied to municipal and domestic users, tend to consume relatively more water than systems that primarily supply domestic users.

In projecting water consumption, estimating equations were determined by regression analysis. Three factors explained more than 90 percent of regional variations: the number of urban places in each region, industrial uses of public supplied water relative to municipal and domestic uses, and nonagricultural regional output per capita for urban populations. To a large degree, these factors reflect the efficiency of public water systems and the patterns of water use in each region.

In regions with large numbers of urban places and sizable concentrations of population, public water systems probably tend to be more efficient, thereby reducing losses resulting from leakages, because of the need to plan and maintain extensive distribution systems. The size of the system also influences the quality of system management and the availability of trained personnel.

Finally, the nonagricultural output per capita of urban population in each region reflects the structure of regional industry and industrial patterns of water use. Large manufacturing output per capita, probably indicating concentrations of heavy industry, results in larger relative consumption than low output per capita, indicating little manufacturing activity or concentrations of light industry only.

Table 70. Industrial and Commercial Requirements for Water from Public Supplies, 1960 and Projected 1980 and 2000

(Million gallons per day)

Region	1960 (actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
United States[a/].....	6,582	12,541	13,205	13,428	18,523	20,876	22,502
Northeast.........	1,828	3,133	3,304	3,363	4,500	5,076	5,470
North Central.....	2,190	3,688	3,886	3,956	5,360	6,073	6,561
South.............	1,520	2,938	3,084	3,136	4,694	5,296	5,707
West:[a/]..........	1,044	2,782	2,931	2,973	3,969	4,431	4,764
Montana.........	19	45	47	48	64	71	77
Idaho...........	56	135	145	147	190	213	230
Wyoming.........	12	23	24	25	33	36	39
Colorado........	78	233	247	251	355	396	428
New Mexico......	12	31	33	33	48	53	57
Arizona.........	21	75	80	81	123	140	148
Utah............	12	33	35	35	52	58	63
Nevada..........	14	56	59	61	96	107	115
Washington......	310	786	811	822	1,043	1,164	1,240
Oregon..........	130	292	310	315	358	400	431
California......	380	1,073	1,140	1,155	1,607	1,793	1,936

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a/ Excludes Alaska and Hawaii.

Source: 1960 data from [3].

Some technological changes can be anticipated during the next 30 years. Also, as urban areas grow, it can be anticipated that public water systems will become more efficiently managed and maintained. The medium projections of the consumption of water used from public supplies are 3.7 billion gallons per day in 1980 and 4.3 billion gallons per day in 2000 (table 71). From a total of 34.8 billion gallons per day which will be withdrawn for public supplies in 1980, 31.2 billion gallons will be returned to the watershed. In 2000 from a total of 50.3 billion gallons withdrawn, more than 46 billion gallons per day will be returned (table 72).

Water Requirements for Self-Supplied Industry

As indicated above, most industrial water in the United States is self-supplied by the water-using industries. Because a prerequisite for establishing a water-using industry in any given location is the availability of water, industrial water use, second only to irrigation as the major use of water, is largely concentrated east of the Mississippi River. Further, again in contrast to irrigation uses, only a small part of water used by industry is consumed. In 1960, about 2 percent of the total industrial water used was consumed.

Water has many industrial uses, including processing, cooling, washing, conveyance of materials, boiler fuel, and sanitation. Because of varying quality requirements for water for industrial uses, almost 25 percent of industrial water is saline. About two-thirds of industrial water withdrawn in the West is saline, whereas only 20 percent is saline in the East.

In projecting the overall requirements for self-supplied industrial water in the various regions, use was made of the ratio of public supplied per self-supplied water. There were two reasons for relying on this ratio. First, regression analysis of public supplied industrial water indicated that industrial structure, manufacturing output relative to other economic activity, was a major determinate of public supplied industrial water use. The projections of industrial structure required to project the industrial use of public supplied water also apply to projections of self-supplied water.

Second, the ratio reflects the availability of water in each region for industrial use. Regions where water is readily available attract large water-using industries; that is,

Table 71. The Consumption of Water from Public Supplies, 1960 and Projected 1980 and 2000

(Million gallons per day)

Region	1960 (actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
United States[a].....	3,434	3,561	3,679	3,861	4,032	4,251	4,712
Northeast.........	653	797	823	864	865	883	1,000
North Central.....	736	816	843	885	883	960	981
South............	1,175	1,145	1,183	1,240	1,297	1,336	1,514
West:[a]...........	870	803	830	870	987	1,072	1,217
Montana.........	56	43	45	47	52	56	64
Idaho...........	18	14	15	15	17	18	21
Wyoming.........	34	24	25	26	30	33	37
Colorado........	69	61	63	66	72	78	89
New Mexico......	49	47	48	51	65	70	80
Arizona.........	74	83	86	90	109	120	135
Utah............	45	39	40	42	50	54	62
Nevada..........	42	64	65	69	74	80	91
Washington......	77	56	58	61	70	76	86
Oregon..........	36	31	32	33	35	38	43
California......	370	341	353	370	413	449	509

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a/ Excludes Alaska and Hawaii.

Source: 1960 data from [3].

Table 72. Projections of the Discharge of Water from Public Supplies, 1960 and Projected 1980 and 2000

(Million gallons per day)

Region	1960 (actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
United States[a].....	17,074	29,923	31,158	32,282	41,561	46,079	50,912
Northeast.........	4,527	6,379	6,657	6,884	8,544	9,533	10,520
North Central.....	4,702	7,547	7,872	8,141	10,333	11,485	12,556
South............	3,728	7,598	7,897	8,189	10,844	12,062	13,371
West:[a]...........	4,117	8,399	8,732	9,068	11,840	12,999	14,465
Montana.........	57	146	152	158	195	214	238
Idaho...........	100	218	230	237	295	327	359
Wyoming.........	24	67	69	72	90	98	111
Colorado........	229	489	511	529	703	777	858
New Mexico......	59	154	160	166	244	266	299
Arizona.........	77	263	275	286	425	470	521
Utah............	177	309	320	336	461	502	566
Nevada..........	37	158	165	173	235	260	286
Washington......	693	1,320	1,362	1,400	1,748	1,931	2,108
Oregon..........	354	624	652	676	794	965	968
California......	2,310	4,651	4,836	5,035	6,650	7,279	8,151

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a/ Excludes Alaska and Hawaii.

Source: 1960 data from [3].

industries most likely to rely on self-supplies. In the regions where water is scarce, industries which use little water and can rely on public supplies are more likely to develop. By projecting the 1960 ratios to remain constant, it is assumed that the growth of large water-using industries relative to small water-using industries in any given region will remain constant.

In 1960, the amount of water used for fuel electric power was more than two-thirds of all industrial self-supplied water (more than 102 billion gallons per day). Although thermal electricity generation is projected to increase several fold by 2000, it was assumed that withdrawals of water used in the generation of thermal electric power will increase at about the same rate as that for other industrial increases. This assumption is based on anticipated technological changes which reduce the quantities of water consumed in generating electricity, and on the increasing ability of generating plants to recirculate and reuse larger percentages of water withdrawn.

In 1980, the medium projection for industrial self-supplied water is 276.4 billion gallons per day. By 2000, it is projected that self-supplied industries will use 445.2 billion gallons per day (table 73).

Water Requirements for Irrigation

The use of water in the United States for irrigation accounts for approximately 40 percent of the total water withdrawn from ground and surface supplies for all purposes (excluding water power) and 80 percent of the annual consumption of water. Unlike the uses made of water for domestic and industrial purposes, irrigation consumes about 60 percent of the water actually delivered to farms. In addition, substantial losses are also incurred in the conveyance of surface water between supply sources and actual acreage under irrigation.

For the purpose of this study, estimates were made of withdrawal, delivery, conveyance loss, consumption, and discharge. Of particular significance is the fact that three-fourths of all water consumed through irrigation occurs in the western States, where almost two-thirds of the irrigated acreage were located in 1960. Projections of water used for

Table 73. Projections of Self-Supplied Industrial Water Withdrawn, 1960 and Projected 1980 and 2000

(Million gallons per day)

Region	1960 (actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
United States[a/]	139,252	262,361	276,365	281,050	394,737	445,208	480,183
Northeast.........	31,393	54,017	56,965	57,983	77,586	87,517	94,310
North Central.....	45,326	76,833	80,958	82,417	111,667	126,521	136,687
South............	49,150	94,774	99,484	101,161	151,419	170,839	184,097
West:[a/]	13,383	36,737	38,958	39,489	54,065	60,331	65,089
Montana.........	260	616	644	658	877	973	1,055
Idaho...........	180	434	466	473	611	685	740
Wyoming.........	150	287	300	312	412	450	487
Colorado........	330	987	1,047	1,064	1,504	1,678	1,814
New Mexico......	45	116	124	124	180	199	213
Arizona.........	130	463	494	500	759	864	914
Utah............	300	825	875	875	1,300	1,450	1,575
Nevada..........	48	192	202	209	329	366	394
Washington......	740	1,876	1,936	1,962	2,489	2,778	2,959
Oregon..........	1,200	2,704	2,870	2,917	3,315	3,704	3,991
California......	10,000	28,237	30,000	30,395	42,289	47,184	50,947

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a/ Excludes Alaska and Hawaii.

Source: 1960 data from [3].

irrigation purposes were based on ratios which were developed from data on withdrawals of average annual consumption, losses, etc., per acre under irrigation.

Data behind the projections were drawn from two sources. The USGS provided estimates of acres under irrigation and water delivered, consumed, and lost in conveyance, by State, for the year 1960. The U.S. Department of Agriculture (USDA) provided irrigated acreage requirements for the years 1980 and 2000.[1] The two series of data for irrigated acreage were not directly comparable, however, because of a basic difference in the measurement of acreage by the two agencies, and because the USDA projections were on a water basin, rather than a State, basis. The procedures used by the two agencies in developing irrigated acreage figures during the 1959-60 period produced a differential of approximately 6 million acres -- 39 million acres estimated by USGS versus 33 million million acres estimated by USDA. Allowing for the downward bias inherent in the USDA census-taking method and the upward bias of the USGS, the true figure probably lies somewhere between the two estimates.

In 1960, it is estimated that 39 million acres were irrigated. The medium projection for 1980 calls for more than 46 million acres to be irrigated. By 2000, it is expected that 53.3 million acres will be irrigated (table 74).

The term "withdrawal" refers to the total diversion of water from surface or underground sources for the specific intent of applying this water to land carrying either cash or fodder crops. Water withdrawn for irrigation is almost always the result of prior capital investment projects, such as well drilling in the case of ground water supply, and storage facilities as provided by single or multipurpose dams for retaining surface water. It is important to note, therefore, that future levels of water used for irrigation implicitly assume not only forecasted acreage requirements but also the capital improvements necessary to store, transport, and apply water to this acreage. Because of the major role taken by Federal and

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[1] U.S. Forest Service and Economic Research Service. Preliminary Projections of Economic Activity in the Agricultural, Forestry and Related Economic Sectors of the United States and Its Water Resource Regions: 1980, 2000, and 2020. Unpublished mimographed report for the Water Resource Council. July 1967.

Table 74. Irrigated Acreage, 1960 and Projected 1980 and 2000
(thousand acres, except where noted)

Region	1960 (Actual)	1980			2000			Percent increase 1960-2000
		Low	Medium	High	Low	Medium	High	
United States[a]...	39,000	46,332	50,550	51,969	48,891	53,338	54,835	--
Northeast.......	170	301	328	338	355	386	397	127
North Central...	4,102	4,741	5,170	5,320	5,004	5,457	5,615	33
South..........	10,238	14,536	15,869	16,313	15,568	16,996	17,472	66
West[a]..........	24,490	26,754	29,183	29,998	27,964	30,499	21,351	--
Montana.......	2,000	2,259	2,440	2,530	2,334	2,520	2,613	26
Idaho.........	3,200	3,473	3,808	3,918	3,619	3,968	4,083	24
Wyoming.......	1,400	1,543	1,736	1,736	1,581	1,778	1,778	27
Colorado......	3,200	3,881	4,256	4,379	3,969	4,352	4,478	36
New Mexico....	930	928	995	1,062	928	995	1,062	7
Arizona.......	1,300	1,114	1,248	1,248	1,103	1,235	1,235	(5)
Utah..........	1,200	1,265	1,356	1,447	1,288	1,380	1,472	15
Nevada........	600	746	746	746	759	759	759	15
Washington....	1,000	1,092	1,190	1,229	1,138	1,240	1,281	24
Oregon........	1,600	1,733	1,888	1,926	1,792	1,952	1,991	22
California....	8,000	8,720	9,520	9,777	9,453	10,320	10,599	29

a/ Excludes Alaska and Hawaii.

Source: Projections based on irrigation acreage estimates for 1960 [3] and percentage increases, 1960-80 and 1960-2000, by USDA (U.S. Forest Service and Economic Research Service. Preliminary Projections of Economic Activity in the Agricultural, Forestry, and Related Economic Sectors of the United States and Its Water Resource Regions: 1980, 2000, and 2020. Unpublished mimeographed report for the Water Resource Council. July 1967).

State Governments in the provision of such facilities, particularly in the western States, government policies concerning water development projects were an important consideration in the estimates in this report.

In 1980, the most likely estimate for water withdrawals for irrigation is 130.4 billion gallons per day, compared with 106 billion gallons in 1960. The medium projections for 2000 is 135.3 billon gallons per day (table 75).

Conveyance loss refers to water losses between the point of withdrawal and delivery to the farm. This type of loss results from both surface evaporation and transpiration by phreatophytes, or deep-rooted plants, which live in the irrigation ditches and canals. Conveyance loss in the case of ground water supply systems is small because such water is either applied directly to the soil from the wellhead or is transported short distances in open trenches under arid climatic conditions. It is recognized that not all conveyance loss results in depletion; seepage back into acquifers occurs in unlined canals. However, no attempt was made in this report to estimate the amount so recovered from such discharge.

The medium projection of total farm deliveries of irrigation water are 103 billion gallons per day in 1980 and 108 billion in 2000. This compares with total deliveries of 83 billion gallons in 1960 (table 76). Conveyance losses amounted to 23 billion gallons per day in 1960. For both 1980 and 2000, conveyance losses are projected to be approximately 27 billion gallons per day (table 77).

Consumption of water for irrigation purposes represents another form of direct water loss through the transpiration of the plants being irrigated. The average annual consumption rate per acre depends on a number of interrelated factors, including the type of crop, the intensity of application, and the supply source. Where the cost of water is relatively high, as in the case of ground water, the application will be more selective as to crop and more carefully controlled than in those areas drawing upon abundant cheap water supplies. Consumption per acre in the western States is approximately twice as high as in the South or Midwest and three times that in the Northeast. As might be expected, however, variation in consumption among the western States is much less pronounced.

Table 75. Water Used for Irrigation - Withdrawal, 1960 and Projected 1980 and 2000

(Million gallons per day)

Region	1960 (actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
United States[a/].....	106,046	119,470	130,400	134,030	123,890	135,270	138,960
Northeast.........	78	140	150	160	160	180	180
North Central.....	6,010	6,850	7,480	7,690	7,120	7,780	7,990
South............	14,908	20,990	22,920	23,560	22,270	24,320	25,000
West:[a/]..........	85,050	91,490	99,850	102,620	94,340	102,990	105,790
Montana.........	6,800	7,580	8,190	8,490	7,740	8,360	8,660
Idaho...........	16,000	17,100	18,740	19,290	17,530	19,220	19,770
Wyoming.........	4,400	4,780	5,370	5,370	4,820	5,430	5,430
Colorado........	9,930	11,980	13,150	13,520	12,200	13,380	13,760
New Mexico......	2,370	2,340	2,510	2,680	2,310	2,480	2,650
Arizona.........	5,800	4,930	5,510	5,510	4,830	5,400	5,400
Utah............	4,170	4,350	4,670	4,980	4,390	4,710	5,020
Nevada..........	2,080	2,330	2,330	2,330	2,340	2,340	2,340
Washington......	4,700	5,080	5,530	5,720	5,230	5,710	5,890
Oregon..........	6,300	6,740	7,340	7,500	6,890	7,510	7,650
California......	22,500	24,280	26,510	27,230	26,060	28,450	29,220

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a/ Excludes Alaska and Hawaii.

Source: 1960 data from [3].

Table 76. Water Used for Irrigation, Delivered to Farms, 1960 and Projected 1980 and 2000

(in millions of gallons per day)

Region	1960	1980			2000		
		Low	Medium	High	Low	Medium	High
United States[a/]....	83,014	94,830	103,480	106,370	99,430	108,520	111,500
Northeast........	78	140	150	160	160	180	180
North Central....	4,386	5,070	5,530	5,690	5,340	5,830	5,990
South...........	12,260	17,400	19,000	19,530	18,630	20,340	20,910
West[a/]..........	66,300	72,220	78,800	80,990	75,300	82,170	84,420
Montana........	5,100	5,760	6,220	6,450	5,950	6,430	6,660
Idaho..........	11,000	11,940	13,090	13,470	12,440	13,640	14,030
Wyoming........	3,100	3,420	3,840	3,840	3,500	3,940	3,940
Colorado.......	9,000	10,910	11,970	12,310	11,160	12,240	12,590
New Mexico.....	1,800	1,800	1,930	2,060	1,800	1,930	2,060
Arizona........	4,700	4,030	4,510	4,510	3,990	4,460	4,460
Utah...........	3,400	3,580	3,840	4,100	3,650	3,910	4,170
Nevada.........	1,700	1,920	1,920	1,920	1,950	1,950	1,950
Washington.....	3,700	4,040	4,400	4,550	4,210	4,590	4,740
Oregon.........	4,800	5,200	5,660	5,780	5,380	5,860	5,970
California.....	18,000	19,620	21,420	22,000	21,270	23,220	23,850

a/ Excludes Alaska and Hawaii.

Source: 1960 data from [3].

Table 77. Water Used for Irrigation, Conveyance Loss, 1960 and Projected 1980 and 2000

(In million gallons per day)

Region	1960 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Northeast..........	0	0	0	0	0	0	0
North Central.......	1,624	1,780	1,950	2,000	1,780	1,950	2,000
South..............	2,658	3,590	3,920	4,030	3,650	3,980	4,090
West:[a/]............	18,750	19,270	21,050	21,630	18,040	20,820	21,370
Montana..........	1,700	1,820	1,970	2,040	1,790	1,930	2,000
Idaho............	5,000	5,160	5,650	5,820	5,090	5,580	5,740
Wyoming..........	1,300	1,360	1,530	1,530	1,320	1,490	1,490
Colorado.........	930	1,070	1,180	1,210	1,040	1,140	1,170
New Mexico.......	570	540	580	620	510	550	590
Arizona..........	1,100	900	1,000	1,000	840	940	940
Utah.............	770	770	830	880	740	800	850
Nevada...........	380	410	410	410	390	390	390
Washington.......	1,000	1,040	1,130	1,170	1,020	1,120	1,150
Oregon...........	1,500	1,540	1,680	1,720	1,510	1,650	1,680
California.......	4,500	4,660	5,090	5,230	4,790	5,230	5,370
United States[a/].....	23,032	24,640	26,920	27,660	24,460	26,750	27,460

a/ Excludes Alaska and Hawaii.

Source: 1960 data from [3].

The consumption of irrigation water in 1960 was approximately 51 billion gallons per day. The medium projections of consumption in 1980 and 2000 are 64 and 67.4 billion gallons per day, respectively (tables 78 and 79).

The first step in this projection required the calculation of delivery, consumption, and conveyance loss, as related to the acreage estimates by region made by USGS in 1960. The next step was the determination of the regional growth rates, as developed from the most recent data prepared by USDA. In developing these growth rates it was necessary to combine river basins into regions, as defined in this report, and, in the case of a few States (Oregon, Montana, Wyoming, and Colorado), to develop a weighted average growth rate based on the approximate acreage distribution of their territories in different river basins.

The delivery, consumption, and conveyance loss rates per irrigated acre were then applied to the acreage projections. Anticipating the results of current and continuing research programs directed toward the reduction of evaporation from storage facilities and the eradication of phreatophytes, the conveyance loss estimates were reduced 5 percent for 1980 and 10 percent for 2000. From the estimates of these three series, it was possible to determine withdrawal (the sum of deliveries plus adjusted conveyance losses) and discharge (the difference between deliveries and consumption).

Of particular importance in the assessment of the projections are the assumptions underlying the USDA estimates of acreage under irrigation for the years 1980 and 2000. The first set of assumptions are socio-economic and are summarized as follows (all figures in millions except PCI):

	1980	2000
Population..................	245.3	338.2
Employment..................	94.3	130.6
Gross national product (1954 dollars).............	1,001	2,144
Personal income (1954 dollars).....................	785	1,680
Per capita income (1954 dollars).....................	3,200	4,967

Table 78. Water Used for Irrigation, Consumption, 1960 and Projected 1980 and 2000

(In million gallons per day)

Region	1960 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Northeast..............	74	130	140	150	150	170	170
North Central..........	3,017	3,490	3,800	3,910	3,680	4,010	4,130
South..................	8,849	12,560	13,710	14,100	13,450	14,690	15,100
West:[a]	39,160	42,520	46,390	47,780	44,480	48,530	49,870
Montana................	2,400	2,710	2,930	3,040	2,800	3,020	3,140
Idaho..................	4,500	4,880	5,350	5,510	5,090	5,580	5,740
Wyoming................	1,900	2,090	2,360	2,360	2,150	2,410	2,410
Colorado...............	4,800	5,820	6,380	6,670	5,950	6,530	6,720
New Mexico.............	1,300	1,300	1,390	1,480	1,300	1,390	1,480
Arizona................	2,900	2,490	2,780	2,780	2,460	2,760	2,760
Utah...................	2,300	2,430	2,600	2,770	2,470	2,650	2,820
Nevada.................	960	1,090	1,090	1,090	1,100	1,100	1,100
Washington.............	1,300	1,420	1,550	1,600	1,480	1,610	1,670
Oregon.................	2,800	3,030	3,300	3,370	3,140	3,420	3,480
California.............	14,000	15,260	16,660	17,110	16,540	18,060	18,550
United States[a]	51,100	58,700	64,040	65,940	61,760	67,400	69,270

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a/ Excludes Alaska and Hawaii.

Source: 1960 data from [3].

Table 79. Water Used for Irrigation, Discharge, 1960 and Projected 1980 and 2000

(In million gallons per day)

Region	1960 (Actual)	1980 Low	1980 Medium	1980 High	2000 Low	2000 Medium	2000 High
Northeast..........	4	10	10	10	10	10	10
North Central......	1,369	1,580	1,730	1,780	1,660	1,820	1,860
South..............	3,401	4,840	5,290	5,430	5,180	5,650	5,810
West:[a/]...........	27,140	29,700	32,410	33,210	30,820	33,640	34,550
Montana..........	2,700	3,050	3,290	3,410	3,150	3,410	3,520
Idaho............	6,500	7,060	7,740	7,960	7,350	8,060	8,290
Wyoming..........	1,200	1,330	1,480	1,480	1,350	1,530	1,530
Colorado.........	4,200	5,090	5,590	5,640	5,210	5,710	5,870
New Mexico.......	500	500	540	580	500	540	580
Arizona..........	1,800	1,540	1,730	1,730	1,530	1,700	1,700
Utah.............	1,100	1,150	1,240	1,330	1,180	1,260	1,350
Nevada...........	740	830	830	830	850	850	850
Washington.......	2,400	2,620	2,850	2,950	2,730	2,980	3,070
Oregon...........	2,000	2,170	2,360	2,410	2,240	2,440	2,490
California.......	4,000	4,360	4,760	4,890	4,730	5,160	5,300
United States[a/]....	31,914	36,130	39,440	40,430	37,670	41,120	42,230

[a/] Excludes Alaska and Hawaii.

Source: 1960 data from [3].

The second assumption is a politico-economic one. Underlying the projection for 1980 is the assumption that Federal water development projects now approved or on record awaiting authorization to proceed prior to 1980 will be implemented. After that date, no specific Federal programs are built into the forecast. Privately developed irrigation projects are not affected by this decision and are assumed to proceed during the forecast period at their previous historical rate. High and low estimates also follow from this assumption and are based on the percentage variations in 1980 between the low, medium, and high estimates of agricultural product originating, as projected elsewhere in this report.

CHAPTER X

LITERATURE CITED

1. Landsberg, Hans L., Leonard L. Fischman, and Joseph L. Fisher. Resources in America's Future. Baltimore: Johns Hopkins Press, 1963.

2. U.S. Bureau of the Census. County and City Data Book. Washington, D.C. : Government Printing Office, 1962.

3. U.S. Geological Survey. Estimated Use of Water in the United States 1960. Circular 456. Washington, D.C.: Government Printing Office, 1961.

INTRODUCTION TO APPENDIXES

The technical appendixes to this report present the more detailed calculations and derivations made during the course of the study to allow further refinement of the projections by others, and to provide a basis for comparisons with other studies. Also, the appendixes provide detailed explanations of the methodology used for the projections, and present the historical data from which trends were determined. When used in conjunction with the text of the report, the appendixes should allow others to reconstruct most of the projections contained in the report.

APPENDIX TO CHAPTER II

NATIONAL AND REGIONAL AGGREGATES

Population

The opinions of several demographic experts consulted during the study indicated that population projections based on the Census Bureau Series C assumptions are most likely to reflect demographic characteristics of the United States in 1980 and 2000. For this reason, Series C assumptions were used for the medium projections in this study.

Statistical Considerations

Historically, fertility rates in the United States were much higher than the rates of recent decades. From a fertility rate of 126 per 1,000 women of childbearing age in 1914, there was a fairly steady decline to a low of 76 to 79 in the period 1933-39; the rate increased to 94 in 1943, and increased again after World War II.

There has been a decline in the birth rate from 1961 to the present, and current statistics do not show any leveling off. The decline has occurred not only in the crude birth rate (number of births per 1,000 of total population), but also in the more precise measures of fertility. Specifically, the number of births per 1,000 women between the ages of 15 and 44, which ranged from 117 to 123 per year between 1954 and 1961, declined to 105 for the year 1964 and to 97 and 92, respectively, for 1965 and 1966. Figures for the first three quarters of 1967 indicate a further decline of about 3 points, giving a seasonally-adjusted fertility rate for the 9 months of slightly under 89.

A similar decline in the fertility rate has taken place for women in specific age groups. For example, the age-specific fertility rate for ages 20 to 24, i.e., the number of babies born to women of this age group per 1,000 women in the group, declined from 254 in 1961 to 220 in 1964, and to 197 in 1965 (latest year available). The fertility rate for the 25-to-29 age group also declined, from 198 in 1961 to 169 in 1964, and to 162 in 1965. These are the age groups which account for the majority of total births.

As a statistical curiosity, it may be noted that the birth rate per thousand of total population is even lower now than in the 1930's. This is due to the fact that the proportion of the population in the child-bearing age group is smaller than in the 1930's, and it has no significance for forecasting purposes.

It is not obvious that the low fertility rate of 1967 (or the still lower rates that would result from projecting recent trends into the future) is likely to prevail, or that higher rates, such as those of 1954-61, or something between, can be expected. The current rate would clearly fall below the Census Bureau's Series C projection.

Human Factors

Two factors which will affect the number of children born in the future are the extent of family planning and the number of children desired by each family. The most outstanding fact, agreed to by experts and borne out by the statistics, is that in a large majority of families in the United States the number of children is influenced by the intention of the parents -- births that are determined entirely by biological chance now form a minority of the total. Following are factors which will tend to raise or depress future fertility rates:

There is a possibility that the recent decline in fertility, or some part of it, may be temporary; i.e., not an indication of a continuing downward trend in desired family size, but rather a result of decisions to delay births. As a result, the fertility rate of women in the older age groups may increase. Thus, the result may be a temporary dip from previous fertility levels. This argument would run along the following lines:

For the cohort of women born in 1937, for example, the fertility rate in the 20-to-24 age group (between 1957 and 1961) was higher than the rate which has characterized the same age group since 1961. In the 25-to-29 age of the 1937 cohort (between 1962 and 1966), the rate was not only lower than in the previous 4-year period, but was also lower than the rate which characterized the older cohort of that age between 1957 and 1961. The relatively high fertility rate of the 1937 cohort between 1957 and 1961 may not have reflected a desire to have a greater total number of children but, rather, to have children at an earlier age.

By the same reasoning, it is possible that the cohort of women who were 20 to 24 years old in 1962-66, and had fewer children in that period, will have more children in their 25-to-29 age period than did women in the 25-to-29 age group in previous years. Thus, even without a change in the total number of children planned, the fertility rates for different age groups of women may change.

More broadly, opinions and desires as to family size are likely to be affected by current social/psychological trends, or "fashion." As an example of changes influenced by social/psychological trends, almost half of the women in the cohorts born around 1910 had no children or only one child, whereas only about one-fifth of the women born in the 1930's will have as few children. Future rates might be influenced by social/economic conditions created by the availability of more interesting work and the opening of professions to women, which might tend to make large families less desirable than in recent years. Such trends in the periods from 1968 to 1980 and to 2000 could resemble those of the 1954-61 period, tending toward larger families, or of some other period, resulting in smaller families.

It is clear that the low fertility rates of 1931-41 (the only years in which rates were lower than current rates) were the result of economic depression. It does not seem likely that a depression period like the 1930's or anything approaching it will occur between now and 2000, and it is possible that increasing affluence will increase the willingness to share family resources with more children.

Conversely, to people born after 1945 and raised in relative affluence, circumstances in the future may not appear to be so affluent as to provide a surplus for supporting large families. Perhaps the high birth rate in the 1950's was related to the fact that life in that period seemed luxurious to people who had been raised in the 1930-45 period; it is doubtful that such a contrast will recur in the coming decades.

The recent military mobilization and, especially, the posting of troops outside the United States have probably been among the causes of the continuing decline in the fertility rate. This study assumes, however, that no major war requiring large-scale mobilization will occur prior to 2000.

Unwanted children are born because of ignorance or neglect in regard to the use of birth control techniques. To the extent that this is the result of some combination of ignorance and poverty, the number of such births is likely to diminish over future years as affluence and the general level of education increase.

A further influence in reducing the number of births is the development of drugs and devices which will make contraception more convenient and/or more acceptable to many people. Scientific developments in this direction are likely to occur in the coming years.

Birth control is especially likely to become more important for the nonwhite population. A 1960 survey of attitudes and behavior associated with family planning indicated that nonwhite couples tend to want fewer children than white couples, but have been much less successful than white couples in controlling family size [16, pp. 349-50].[1]

Apart from possible changes in the official position of the Roman Catholic Church on birth control practices, there may occur differences among the points of view of Catholics which may affect individual decisions in Catholic families.

Rural families, and especially farm families, have consistently had more children than urban families. The trends indicate, however, that the rural population, and especially the portion consisting of farmers, is likely to continue to diminish relative to the general population.

Regional Population Projections to 1980

The Census Bureau projects two separate series under migration assumption II (which assumes regional migration equilibrium in 2010). One series incorporates the Census Series B (high-fertility assumption), and the other incorporates the Census Series D (low-fertility assumption). To make regional projections consistent with the national

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[1] Figures in brackets in the appendixes refer to the Literature Cited at the end of the corresponding chapter.

population projections, the regional figures of the Bureau of Census were treated as follows:

(1) Since the national low population projection incorporates a Series D fertility assumption, the II-D regional projections (migration assumption II and Series D fertility assumption) were used for the regional low population projections for 1980.

(2) To derive the regional medium and high projections, which reflect (respectively) the Series C fertility rate and the mid-point between Series A and B, some adjustment was necessary. For the regional medium projections, the ratio of the Series C to Series D projections of the national population was used. Each II-D migration regional projection to 1980 for the regions was multiplied by the C/D ratio, or 1.0331. For regional high projections, the II-D migration projections for the region were multiplied by (A + B)/2D, or 1.0844. It will be noticed that the approximations differ slightly when summed from the corresponding national projections (in 1980). The reason is that national projections include Armed Forces overseas, whereas the regional projections exclude them.

Regional Population Projections to 2000

To project regional population for 2000, population trends based on historical series and Census projections were determined for each region for the period 1950 to 1985. These trends, with regional populations expressed as percentages of national population, were then projected to 2000.

Urban and Rural Population Projections

The urban and rural population projections were based on projections made by the Bureau of Public Roads (BPR) for 1975 and 1985.[2] Adjustments were required because BPR accepted the Census Series B assumptions rather than the Series C assumptions used throughout this study. The percentages of the national and regional populations which will be urban in 1980 were calculated, by interpolation, from the adjusted projections.

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[2] Unpublished estimates of urban and rural population in 1975 and 1985, U.S. Bureau of Public Roads, 1965.

To determine national and regional urban populations in 2000, it was assumed that for the Nation and regions the increase of urban population expressed as a percentage of total population between 1985 and 2000 would equal the increase in this percentage between 1975 and 1985. Thus, an assumption of a diminishing rate of increase of urban population as a percentage of the total population of the Nation and of each region was incorporated in the projections. The ratios of urban populations to total populations were then applied to the national and regional medium projections for 2000. These percentages were also applied to the high and low regional total population figures to determine regional high and low urban and rural populations.

Labor Force and Employment

National Labor Force Projections

Prior to 1967 the Bureau of Labor Statistics (BLS) based labor force statistics on a definition of the population of working age as 14 years and over. Because this definition was changed to increase the age of potential entry into the labor force to 16 years in 1967, it was necessary to adjust the 1965 BLS projections of the labor force participation rates to 1980. For the national projections, the adjustments were made by deleting the participation rates of persons under 16 years of age from the national averages. The adjustment of regional rates was somewhat more complicated because the BLS projections did not specify rates for persons between 14 and 16 years of age.

Regional Labor Force Projections

In order to make the regional labor force participation rates consistent with the national rates, the percentage difference between the projected participation rate of each region and the projected national rate (unadjusted) was computed. These differences were then applied to the adjusted projection of the national participation rate. It was assumed, therefore, that the relationship between the participation rate in each region and the national rate remained unchanged even though the definition of the population of working age was modified.

In order to apply the projected rates to the population of working age in each region, it was necessary to project regional populations of 16 years and over. (The Bureau of Census does not use age 16 as a breaking-point in its regional projections.)

By dividing the national population projection of 16 years and over for 1980 (166,553,000) by the Census Bureau's population projection of the population 18 years and over for the same year (157,251,000), the projected national population of 16 years and over was found to be 1.05945 times the population 18 years and over. Multiplying this coefficient (1.05945) by the Census Bureau's regional projections of population 18 years and over, estimates of the regional populations of 16 years and over were obtained for each region for 1980. (The Bureau of the Census agreed with this method, and conceded that only in States with relatively large Negro populations would there be any significant error. Since the concern of this study is primarily with the western States, which have a relatively small Negro population, it may be concluded that the variance between States due to differing percentages of 17- and 18-year olds will be slight.)

To project a medium, high, and low labor force by region, three participation rates (high, low, and medium) were multiplied by regional projections of populations 16 years and over. (Because all people in the 16-and-over category by 1980 are already born, only one set of population figures was used.)

In projecting national and regional labor force to 2000, it was necessary to make medium, high, and low projections of regional populations of 16 years and over from the national and regional population projections to 2000, and to make medium, high, and low projections of regional participation rates.

Given regional total population projections for 2000, it was assumed that by 2000 the existing variations in age distribution among regions would be insignificant, and that it would be reasonable to assume a uniform age distribution in all regions. Thus, the medium, high, and low figures for the national population of 16 years and over divided by total medium, high, and low national populations yielded the coefficients by which each region's total population figure was multiplied. The resulting percentages were 70.20 for the medium population projection, 66.42 for the high projection (a lower percentage because the high projection would include many more young people in the under-16 category), and 72.85 for the low projection. Applying these to each region's medium, high, and low population figures, high, medium, and low projections were made for each region's population of 16 years and over.

The trend for each region's labor participation rate as a percentage of national participation rates from 1960 to 1980 was then determined. These trends were extrapolated to 2000, taking into account the assumption that there would be a tendency toward uniformity in regional labor force participation rates; i.e., that deviations of regional participation rates from national participation rates will become less pronounced over time.

The projected regional participation rates as percentages of national participation rates were then multiplied by the low, medium, and high national labor force participation rates projected for 2000; i.e., by 55.1, 62.3, and 63.1 percent, respectively. These rates were then multiplied by the low, medium, and high populations of working age.

Regional Employment Projections

In all projections of regional economic characteristics, it was assumed that there will be a constant trend toward a diminution of interstate differentials. A variable most sensitive to this trend is the regional differentials in levels of unemployment. Given the mobile nature of the labor force, the homogeneous nature of the American economy, and the increasing government programs in promoting regional growth, the likelihood of great unemployment differentials among States is decreasing. For example, regional unemployment relative to national unemployment during the period 1950-60 indicates a consistent trend toward a lessening of regional differences.

The basic method for projecting low, medium, and high regional employment for 1980 and 2000 was to begin with ratios of regional national unemployment rates for 1950 and 1960. The 1950-60 trend of this ratio was then projected to 1980. When the State-to-National ratio was over 100 in 1950 and 1960 and a linear trend would have placed it under 100 by 1980 (or when it was below 100 in 1950 and 1960 and would have been over 100 by 1980), the 1980 ratio was assumed to be 100. The projected regional low, medium, and high percentages of the

labor force employed (1.00 minus the percentage unemployed) for 1980 were multiplied by the appropriate regional labor force projections for 1980.

In all States and regions except Montana, Idaho, Colorado, and Washington the prospective changes in the regional unemployment level, as a percentage of the national unemployment level, converged to 100 by 1980. The States which did not respond in this manner were treated in the following ways:

(1) In Idaho and Washington the unemployment level relative to the national unemployment level converged toward the national average, but at a relatively slower rate. It was assumed that the average annual rate of change between 1950 and 1960 would continue to 1980 and would result in a percentage unemployment still slightly above the national level.

(2) Montana and Colorado were closer to the national unemployment level in 1950 than in 1960; it was arbitrarily assumed that in 1980 they would be at their 1950 level of unemployment relative to national unemployment.

It was assumed that differentials between regional and national unemployment levels in 2000 would be very small in the above four States, and that for States that are equivalent to the national level in 1980, there was no reason to assume a differential in 2000. It was assumed, therefore, that all regional unemployment rates will equal the national averages of unemployment in 2000.

To project medium employment in 1980 and 2000 by region, the medium labor force by region in 1980 and 2000 was multiplied by our medium national employment rate of 96 percent. However, for the four States for which the projected regional-to-national unemployment ratios in 1980 were different from 100, the following adjustments were made:

(1) The projected 4-percent unemployment rate was multiplied by the projected ratio of State-to-National level of unemployment; (2) the result was subtracted from 100 percent; and (3) the labor force was multiplied by the resulting figure instead of by 96 percent.

To project high and low employment by region for 1980 and 2000, high and low regional labor force figures for 1980 and 2000 were multiplied by the high national employment rate of 97 percent and the low rate of 95.5 percent, respectively. For the four States for which adjustments were made in calculating the medium employment projection, similar adjustments were made in calculating the high and low projections.

Productivity

In assuming that the historical average annual changes in productivity in the United States (1948-65) will prevail until 1980 and 2000, it was also assumed that positive and negative factors which could influence future productivity rates would tend to offset one another.

One positive factor contributing to changes in productivity might be that the momentum of technological progress would tend to increase productivity more rapidly in the future than in the recent past. Another positive factor is the increasing extent to which the labor force will be educated and trained in the future.

A negative factor is that the productivity increases which have resulted from the movement of persons out of agriculture, with its lower (although rapidly increasing) rate of productivity, into manufacturing, with its higher rate, are certain to diminish.

The shift of employment from industrial to service activities can be expected to continue and to increase. Service activities, for which productivity increases (as customarily measured) have been relatively moderate, could possibly increase productivity through future technological developments. This last point raises the question of how the growth of productivity in services should be measured so that this growth will reflect the changes in the utility of the services produced rather than merely the input of work. In view of the purposes of the present study, it seemed appropriate to assume that service activity increases in productivity would be shown through the use of factor cost as a basis for valuing services. Thus, because qualitative changes in services will not be reflected in the measurement of output, an increase in the service sector relative to other sectors would tend to have a negative impact on average productivity measures.

The prospect of shorter working hours and the effect on output is also an important productivity factor. The NPA study included projections of increases of about 3 percent a year in output per man-hour (slightly above the 1948-65 rate of increase), along with projections of the number of man-hours to be worked. It is doubtful whether such an analysis adds significantly to the reliability of projections of output per employed person. For an increasing proportion of the work performed in the future, output will not vary directly with the hours worked; i.e., the output will vary with the number of persons employed, such as for teaching and other service-oriented occupations.

Another aspect of the changes in hours worked is related to possible changes in the desire of individuals as to how much work they want to do. As overall affluence increases, there will be choices between increasing the production of goods and services as against increasing leisure time. Public policy will be molded in response to public desires in these matters. Preferences for leisure time could result both in people dropping out of the labor force and in their working fewer hours or days per week or year.

Gross National Product

The contract between the Public Land Law Review Commission and Robert R. Nathan Associates, Inc., includes the following:

> An annual rate of increase in GNP of 3.75 percent per annum in real terms will be used for the medium projection, unless this rate appears to be inconsistent with the medium population projections. In that case, appropriate changes will be made after consultation with the Commission.
>
> For the high projection, use an annual rate of increase in GNP of 4.25 percent in real terms. For the low projection, use an annual rate of increase in GNP of 3.25 percent in real terms. If the contractor's work suggests a departure from these assumed rates, the reasons will be fully explained and appropriate changes made after consultation with the Commission.

Consideration of the relevant factors indicated that higher rates of increase for gross national product were more realistic than the rates of increase specified above. After consultation with members of the Commission's staff, the following projected annual rates of increase in GNP were adopted:

	Percent increase	
	From 1965/66 to 1980	From 1965/66 to 2000
Medium	4.4	4.2
High	4.6	4.5
Low	3.8	3.7

These rates of growth would lead to the following projected values for GNP, expressed in billions of 1958 dollars, for 1980 and 2000:

	1980	2000
Medium	1,176	2,603
High	1,211	2,878
Low	1,079	2,200

According to the medium projection, the GNP per employed person will increase during the periods from 1965 to 1980 and from 1965 to 2000 at the rate of 2.6 percent per year. Thus, the GNP per employed person, which was $8,360 in 1965 and $8,590 in 1966, will be about $12,270 in 1980 and $20,450 in 2000 (1958 dollars).[3]

The medium projection for total employment in 1980 is 96.7 million, or 27 percent above 1966, a compound annual increase of 1.73 percent. Combining the results of projected increases in productivity and employment, the medium projection of the rate of increase in GNP is approximately 4.4 percent per year between 1966 and 1980.

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[3] Future productivity levels were projected on the basis of expected rates of growth from the 1965 level of productivity per employed person. For projecting numbers of employed persons, however, it seemed possible to make better projections using 1966 data, and rates of growth were calculated by comparing those projected levels with actual 1966 employment. No inconsistency was introduced by this combined use of 1965 and 1966 data.

For the year 2000, the medium figure for total employment is 129.5 million, a compound annual increase of 1.58 percent from 1966. With the 2.6-percent annual increase in output per employed person, the medium projected increase in real GNP over the whole period is about 4.2 percent per year.

In projecting high and low GNP, two approaches were considered. For the low projection, the procedure was as follows:

First, it was estimated that if various negative factors, included in the discussion of productivity above, should prove to be of importance, GNP per employed person might increase at an annual rate as low as 2.25 percent rather than 2.6 percent. Because the combination of low employment and low productivity is regarded as unlikely, the low productivity projections were combined with our medium employment projections.

Second, low employment projections were considered. However, if employment is low, output per person may be assumed to increase by at least the medium rate of 2.6 percent. In particular, given the assumption that the level of employment will be generally determined by the size of population and labor force participation rates rather than by fluctuations in the demand for labor, the rate of increase in productivity would be maintained, as capital investment occurs to compensate for low employment. Hence, the low employment figure was combined with the medium output figure.

Comparing the results of the two approaches, the second yielded the lower GNP figures for both 1980 and 2000, and these figures were chosen as the low projection. This projection shows the GNP increasing from 1966 to 1980 at an annual rate of 3.8 percent, and from 1966 to 2000 at a rate of 3.7 percent.

Similarly, two approaches were considered for the high projection of the GNP. First, it was estimated that under positive circumstances (described above) the GNP per employed person might increase at a high annual rate of 2.8 percent rather than the 2.6-percent medium rate. This high productivity rate was applied to the medium employment projection. For the alternative approach, the high employment projection was combined with the medium 2.6-percent rate of increase in output per employed person. Again, the combination of extremes, in this case high employment and high productivity, did not seem likely.

Applying these alternatives to the period between 1965 and 1980, the higher of the two approaches, which assumed a 2.8 percent increase in productivity, indicated an annual increase in GNP at a rate of 4.6 percent. For the full period, 1965 to 2000, the second approach, which assumed a 2.6-percent increase in productivity, was the higher of the two, giving an annual increase in GNP of 4.5 percent. These two high rates were therefore chosen as the rates of increase for the high projections.

In projecting GNP on the foregoing basis, it was assumed that unemployment would be 4 percent of the labor force for the medium projection (3 percent and 4.5 percent for the high and low projections, respectively), and that there would be sufficient demand to take up the greatly increased amount of goods and services that the resulting volume of employment would produce.

Gross National Product Components

Projections of GNP Components to 1980

The projections for the components of GNP in 1980 are an extrapolation of NPA projections through 1977 [3,4]. Unlike other available projections, the NPA projections are revised annually on a continuing basis. In addition, the NPA projections result from a judgment model rather than a target model. A judgment model does not necessarily assume that all economic decisions are always correct; rather, it takes into consideration factors such as social attitudes, political adaptability, pressure of interest groups, and the effects of delays and lags in the decision processes.

As stated above, the low, medium, and high projections of GNP to 1980 were made using various plausible permutations of labor productivity and employment. Based on the GNP projections, the components of GNP in 1980 were made by applying extrapolations of NPA projected relationships between GNP and components of GNP from 1977 to 1980.

NPA used the equation:

$$GNP = G + PCE + GPDI + N\ (X-M).$$

GNP = Government purchases of goods and services
+ personal consumption expenditures
+ gross private domestic investment
+ net exports (exports - imports)

Government purchases of goods and services (G). In the NPA report it was assumed, in projecting government purchases of goods and services as a percentage of GNP, that defense expenditures would remain at the 1965 level through 1977.[4] The NPA reasoning was as follows: Whereas defense and general government programs are likely to increase relatively slowly, the domestic programs for growth and welfare will increase to about 60 percent of the estimated total Federal budget. The categories of expenditures which are projected to increase are natural environment, housing, transportation, communications, area development, and the job preparation and education portion of "human skills and social welfare" category [3, p.21]. Government purchases of goods and services as a percentage of GNP projected by NPA are [3, table 3]:

Government purchases of goods and services
as percentage of GNP

1960	1965	1971	1972	1976	1977
19.4	18.3	17.5	17.5	17.4	17.5

Since the Vietnam war is projected to end in the 1965-70 period, the ratio of defense expenditures to GNP is expected to decrease. While social expenditures relative to GNP will increase, they are not expected to increase proportionately to the decrease in defense expenditures. Since NPA projected a relatively constant relationship of government purchases of goods and services to GNP in the 1971-77 period, as shown above, this relationship was projected to remain constant to 1980.

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[4] The NPA projection [3] has been recently revised (not yet published) to incorporate the assumption that the defense expenditure will remain at the 1966 level. Since this study assumed the 1965 defense expenditure level, our projections will mirror the NPA projections, but will differ slightly from the later publication.

Personal consumption expenditure (PCE). In regard to personal consumption expenditures, NPA assumed the following:

(1) As defense expenditures decrease and as government social expenditures increase (but at a slower rate than the rate of decrease in defense expenditures), PCE as a percentage of GNP must increase if recent GNP growth rates are to be sustained.

(2) Factors such as the growth of transfer payments and continually rising household incomes (slightly greater than 3 percent per year) will contribute to increasing PCE as a percentage of GNP. NPA projections are [3, table 3]:

Personal consumption expenditures as percentage of GNP

1960	1965	1971	1972	1976	1977
64.8	64.6	65.8	65.7	65.6	65.6

As a direct result of the short-run effects of the ending of the war by 1970, the PCE/GNP ratio is projected to be at a high in 1971. Thereafter, PCE tapers off to 65.6 percent and can be assumed to rise only slightly through 1980. Thus, PCE is projected to be 65.7 percent of GNP 1980, increasing from 65.6 in 1977.

Gross private domestic investment (GPDI). Since the Vietnam War is assumed to end in the 1965-70 period, NPA projects a lagged increase in GPDI as a percentage of GNP starting in 1972 and moving gradually upward through 1977, and regaining its historical (i.e., 1948 to 1965) relationship of approximately 16 percent of GNP [3]:

Gross private domestic investment as percentage of GNP

1960	1965	1971	1972	1973	1974	1975	1976	1977
14.8	15.8	15.8	15.8	15.9	16.0	16.0	16.1	16.1

It is assumed that the percentage of GPDI to GNP in 1977, 16.1 percent, will continue through 1980.

Net exports and imports (N). Since the period 1965-70 will be affected by relatively large defense expenditures, the period beginning with 1971 has been designated by NPA as the base for projecting the gradual growth of the foreign sector of the American economy. Both the marginal propensity to import and the marginal propensity to export are assumed by NPA to be positive functions of the growth in GNP, with the former increasing at a greater rate since it is not only a function of the growth in GNP but also a function of the growth of PCE [3]:

Net exports and imports as a percentage of GNP

	1960	1965	1971	1972	1973	1974	1975	1976	1977
Exports	5.6	6.1	6.4	6.4	6.5	6.5	6.5	6.5	6.5
Imports	4.7	5.1	5.5	5.5	5.6	5.6	5.7	5.7	5.7

Projections of relationships of imports and exports to GNP were made by extrapolating the trends in the relationships to 1980.

Exports/GNP = 6.5 percent
Imports/GNP = 5.8 percent
Net (exports - imports)/GNP = 0.7 percent

Based on the relationships of the components-of-GNP to GNP, projections of GNP components were made for 1980 by multiplying GNP by the coefficients of the GNP components. The low, medium, and high projections of the components were made by applying the coefficients of the components to the low, medium, and high projections of GNP.

Personal Disposable Income (PDY)

Although the NPA study [3] assumes that personal disposable income will increase in the period 1971-77, the increase is directly proportional to the rise in GNP; therefore PDY/GNP remains constant. Also, although not explicitly noted, it is assumed that the relationship between PCE and PDY will remain constant, PCE/PDY = .9. Since PCE is assumed to be 65.7 percent of GNP in 1980, it follows, therefore, that PDY will be 73 percent of GNP. This relationship was applied to projections of GNP to determine low, medium, and high PDY in 1980.

Projections of GNP Components to 2000

In projecting the components to 2000, as in the 1980 projections, the following equation was used:

$$GNP = G + PCE + GPDI + N (X-M).$$

Government purchases of goods and services (G). Because it is assumed, on the basis of historical series, that the ratio of gross private domestic investment (GPDI) to GNP will remain constant, changes in the composition of GNP will occur mainly in government expenditures for goods and services (G) and personal consumption expenditure (PCE). In 2000, the ratio of (G) to GNP will be a result of a blend of social and economic attitudes developing through time.

The 20th century has witnessed (barring interruptions in depressions and wars and disregarding cyclical fluctuations) a continued growth of GNP, a decreasing PCE as a percentage of GNP, and an increasing G as a percentage of GNP. There has been a growing social awareness of the positive role government can perform in translating broad social ends into comprehensive programs. The Government, with the aid of continually maturing economic expertise, has developed timely variations in fiscal and expenditure policies, which have an important positive effect in sustaining continued economic growth.

Considering all these factors, an increase in the ratio of government expenditures for goods and services to GNP, from 17.5 percent in 1980 to 21.8 percent in 2000, is projected.

Personal consumption expenditure (PCE). That GPDI will remain as a constant function of GNP assumes that personal consumption expenditure (PCE) will remain at about 90 percent of personal disposable income (PDY); i.e., that approximately 90 cents out of each dollar of PDY will be spent for consumption. Even though it can be assumed that consumption patterns by

the year 2000 will change, given the narrowing of the distribution of income about its mean,[5] there are factors that will cause the relationship between PCE and PDY to be maintained:

(1) Food and clothing will become more income inelastic, and expenditures for services will undoubtedly increase; (2) Consumer expenditures for luxury goods and goods of high quality will increase; and (3) There will be increased discretionary purchases, e.g., household appliances, recreation, travel.

From the beginning of the 20th century (not including wars and depressions), PCE has drifted downward from 80 to 75 percent of GNP in the 1920's, to approximately 65 percent in the last decade. The decline has been due to the increasing role of government as the provider of defense and of services not obtainable in the marketplace. If it is assumed that (1) there will be increased government social expenditures, particularly increased coverage of medical and educational services; and (2) increased personal taxation to cover the greater part of these programs (decreases in the PDY/PCE ratio, counterbalanced by an increase in government purchases of goods and services), then it may be assumed that PCE/GNP will decrease even more.

Medical care expenses amounted to $28.1 billion in 1965, or 4.1 percent of GNP, and private education and research were $5.6 billion, or 0.8 percent of GNP. Together, the percentage of GNP was 4.9 [10].

It seems reasonable to assume that two-thirds of the costs of such medical and educational services will be covered by government-sponsored programs in 2000, and that the total expenditures for such services will have risen from 4.9 to about 6 percent of GNP. In that case, the ratio of PCE to

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[5] The expectation of a narrowing distribution of income is based on the following: (1) Even though differentials in living standards in the United States are still great, there is a trend toward narrowing the differentials between regions (e.g., between North and South, see regional projections); and (2) as we raise base incomes without substantially increasing the number of persons earning relatively higher wages and salaries, there will be an increase in the number of people within one standard deviation of the mean income.

GNP will have to be reduced by 4 percent if the services are financed by increased taxation. The factors which account for this are:

(1) The increased quantity and quality of these services will serve as counter-weighing factors. On one hand, increased quantity of these services will mean a larger expenditure by government; on the other hand, increased quality of services and economies of scale will decrease the cost of supplying specific 1966 services in 2000.

(2) Although the majority of the population will probably use publicly supported universities and government will cover all their medical expenses, some may still choose to go to private educational institutions, or use the services of private practitioners at their own expense.

(3) An increased social awareness of the vital government role in promoting continued growth will result in a greater number of government growth programs, particularly in regard to natural environment, housing, transportation, communications, area development, and research and development.

A ratio of PCE to GNP of 61.7 percent is, therefore, projected for 2000, compared with 65.7 percent for 1980.

It is interesting to note that an even lower ratio of PCE to GNP is characteristic of the Scandinavian countries. In Denmark PCE is about 58 percent of GNP, and in Sweden, about 56 percent.

Gross private domestic investment (GPDI). Gross private domestic investment (GPDI) and GNP are directly related in several ways: (1) There is a direct relationship between GPDI and the rate of economic growth; (2) similarly, there is a relationship between GPDI and labor productivity -- the greater the capital/labor ratio, the greater the productive output per employed worker; and (3) as GPDI increases in relation to GNP, consumers and government must decrease present consumption in relation to current output.

Historical series show that between 1948 and 1965, whereas output per employed person increased an average 2.6 percent per year, GPDI remained relatively constant at about 16 percent of GNP. In the projections of GNP components to 1980, the reasoning and figures (projected to 1977) of NPA were followed; thus, GPDI as a percentage of GNP is projected to be 16.1 percent (approximately equivalent to the historical average of 16 percent). For projections to 2000, it is assumed that the GPDI/GNP ratio will continue to be about 16 percent.

Even though the possibility exists that GPDI may be considerably above or below 16 percent of GNP, it is difficult to incorporate this possibility into the high and low projections because there is no a priori reason why a high or low ratio of GPDI to GNP should go with a high or low GNP. In particular, private construction represents about half of GPDI, and residential construction is half of all private construction. As the number of families increases, there is an increased demand for housing starts, independent of the rate of growth in productivity. Thus, about one-fourth of investment has little connection with the growth in productivity.

Imports (M) and Exports (X). For 1980, it is assumed that the marginal propensities to import and export are positive in relation to the growth in GNP, with the increase in imports being the greater because imports are also a positive function of PCE. The same assumptions are used for projections to 2000.

In regard to the 1980 projections (exports 6.5 percent of GNP, imports 5.8 percent of GNP) compared with 1960 (exports 5.6 percent of GNP, imports 4.7 percent), imports increase by 1.1 percentage points, whereas exports would increase by 0.9 over the 20-year period. Continuing these trends to 2000, it is projected that exports and imports in 2000, as percentages of GNP, will be 7.4 and 6.9 percent, respectively.

Personal disposable income (PDY). The historical relationship PCE/PDY = 0.9 can be expected to be maintained through 2000. Since three separate PCE figures for 2000 have been projected, the high, medium, and low PDY is determined from the equation

$$PDY = PCE\ (10/9)$$

FRB Industrial Production Index

In projecting the Federal Reserve Board (FRB) index of industrial production and its components to 1980 and 2000, use was made of the projections (in constant dollars) of the GNP and its components. Following is a brief historical review of the most important relationships:

FRB index (overall). The index points per billion dollars of GNP increased constantly over the period between 1956 and 1965, from .2239 to .2325.

Consumer goods index. The index points per billion dollars of GNP exhibited two distinct cycles: 1948-55, averaging .2093; 1960-65, averaging .2271.

Equipment. The index points per billion dollars of GNP exhibited an increasing trend between 1961 and 1965, but the 1965 level was only slightly higher than the 1956-57 average level.

Materials. The index points per billion dollars of GNP exhibited very short-run (one to two years) cyclical movements, ending in 1965 at a high of .2338.

Total manufacturing. The index points per billion dollars of product from manufacturing increased during the period 1956-61, but by 1965 the average returned to its 1959 level. Considering 1959-65 as a cycle, the average value was .7694.

Durable manufacturing. The index points per billion dollars of durable manufacturing product remained relatively constant over the period 1956-65 at 1.3140.

Nondurable manufacturing. The index points per billion dollars of nondurable manufacturing product increased constantly between 1956 and 1961, from 1.7472 to 1.8599, but fluctuated between 1961 and 1965. The average for the 1961-65 period was 1.8648.

Mining. The index points per billion dollars of product from mining remained constant during the period 1956-65 at an average of 7.736.

Public utilities. The index points per billion dollars of GNP increased constantly between 1956 and 1965 from .1970 to .2609.

In projecting the relationship of the index and its components to GNP for 1980 and 2000, several bases were used.

First, for those components which maintained a constant relationship to GNP during the 1956-65 period (durable manufacturing and mining), it was assumed that the relationship would continue to 1980 and 2000. Similarly, for those components of the index which increased relative to GNP until the 1960's, but which fluctuated thereafter (nondurable manufacturing and total manufacturing), it was assumed that the short-run average (1961-65 for nondurable manufacturing and 1959-65 for total manufacturing) would provide the best projection for 1980 and 2000.

For the index which increased constantly relative to GNP during the period studied (utilities), it was assumed that the historical rate of increase would continue to 1980 and 2000.

The projections for consumer goods, equipment and materials, and the overall FRB index were made by using similar methodology, but incorporating certain value judgments.

For 1980 it was assumed that the consumer goods index relative to GNP would remain at the level of the 1960-65 cycle; for 2000 it was assumed that the relationship between the index and GNP would be at the level of the 1948-55 cycle. The reasoning for this projection was based primarily on a judgment that services will increase relative to goods, as a percentage of GNP, through 2000.

Treatment of the overall FRB index differs from the treatment of the component indexes, in that NPA has published projections for the overall index for the period 1971-77 [3]. Using these projections as a base, it was assumed that the historical average annual rate of increase (1948-65) in index points per billion dollars of GNP would continue to 1980; therefore, the 1977 figure of .2568, projected by NPA, was increased by three times the average annual increase of .00612, yielding an index of .2617 points per billion dollars of GNP in 1980. For 2000, it was assumed that the index would have the same relationship to GNP as in 1965.

That FRB index points per billion dollars of real GNP were projected to increase through 1980 is directly related to NPA's assumptions concerning the composition of GNP, i.e., the goods sector of GNP was projected to increase during these early years at a greater rate than services and government. Since the GNP projections of the present study reflect expectations that services and government will grow as a percentage of GNP with the goods sector declining, it was projected that by 2000 the relationship of the index to GNP would be the same as in 1965.

The relationship of the equipment and materials indexes to GNP showed erratic movements with no consistent trends. In 1965, both the equipment and material index points per billion dollars of GNP were at their highest level. It was assumed that the relationship of these indexes to GNP would change in the same manner as the overall FRB index between 1965 and 2000. This assumption was based on the fact that all three indexes (overall, materials, and equipment) were related to GNP, and that since the overall FRB index is expected to increase relative to GNP until 1980, its two major components, equipment and materials, can be expected to increase at the same rate. Thus, the relationship of the indexes to GNP was projected for 2000 to be the same as in 1965.

Regional Gross Product Originating by Major Industrial Sector

Projections to 1980 and 2000 were made for regional gross product originating (GPO) in each of three industrial sectors: agriculture, manufacturing, and all other. Both national and regional figures for the three sectors are needed in making the commodity projections presented in this report.

Before attempting any projections of regional and sectoral GPO, it was necessary to find an appropriate historical series giving regional figures for each of the industrial sectors. The Office of Business Economics (OBE) does not provide such a series, and the only historical series that closely approximated the requirements of this study were provided in NPA studies [3, 4]. The NPA studies provided State GPO by major industrial sectors for 1947, 1952, 1960, 1962, and 1975 (projected).

Because national GPO and GNP are conceptually equal and differ only because of data problems, GPO was projected to be equal to GNP in 1980 and 2000.

From the NPA report [3] showing national projections to 1976 and 1977, the trends in agriculture and manufacturing were extrapolated as percentages of GNP (from 1971 to 1976) to 1980, yielding:

Agriculture = 2.6 percent of GNP
Manufacturing = 32.8 percent of GNP
Other = 64.6 percent of GNP.

To project the distribution among the regions and States for each sector in 1980, the trends from 1960 to 1975 for sectoral product in each region, expressed as a percentage of the national sectoral product (sum of regional sectors equals total sector), were extrapolated. It was assumed that the average annual rate of change in a region's share of the national sectoral product would continue to 1980. To illustrate:

> If GPO from agriculture in Oregon in 1960 equaled 1.3 percent of total U.S. agricultural produce in 1960, and if it equaled a little more than 1.5 in 1975, then in 1980, agricultural product in Oregon is projected to equal 1.6 percent of total agricultural product.

As indicated above, the product of each sector was calculated as a percentage of total national GPO, and the product of each sector in a region was calculated as a percentage of national sectoral product.

To project low and high values of GPO for regions and sectors, it was assumed that the ratio for each sector as a percentage of national GPO, and for each region in a sector as a percentage of national sectoral product, would be applicable for the entire range (low, medium, and high) of projections. The low, medium, and high projections were calculated, therefore, by applying low, medium, and high projections for national GPO and to the computed regional and sectoral ratios.

Projections of regional and State GPO by the three major industrial sectors for 2000 were determined as follows:

(1) National agricultural GPO in 2000 as a percentage of total national GPO in 2000 was projected to be 1.6 percent. This is considerably lower than the 2.6 percent determined for 1980. The 1.6-percent projection was based on historical trends and other available information which indicate that agricultural product per capita is rather constant and can be expected to remain so in the future. From 1948-65, agriculture increased at an average annual rate of 1.1 percent. For 1965-76, NPA projected an average annual growth rate of 1.4 percent. The projection for 2000 was based on an assumption that agriculture will increase at the 1965-76 rate, reflecting the propensity to consume higher quality agricultural products as personal incomes increase.

Manufacturing, as a percentage of national GPO, is projected to return to its 1965 level of 29.9 percent, reflecting a relative increase in services and government as percentages of GNP.

(2) To project each regional sector as percentages of national sectoral product, it was assumed that during 1980-2000 the change in manufacturing would be one-half of the corresponding 1960-80 change in the same ratio. To illustrate:

> Manufacturing in Wyoming in 1960 equaled .05 percent of total manufacturing. In 1980 it is projected as .03. Therefore, in 2000 it would be projected at .02 of total manufacturing in the USA.

The underlying logic of this assumption is the same as other projections (population, labor force, and employment) where we assumed a trend toward a diminishing or stabilized interstate differential.

Regional and State Personal Income Projections

Whereas projections were made for personal disposable income (PDY) for the United States, for regions and States projections were made for personal income (PY) only. To insure internal consistency, it would have been logical to project PDY at the regional and State levels, but this was not possible for two reasons:

(1) There exists no complete historical series for regional PDY. In 1961 the Bureau of the Census revised the definition for regional personal income but has not, as yet, published a series for (PDY) by regions that is consistent with their new definition.

(2) The difference between (PDY) and (PY) is a function of personal taxes, and to project regional and State personal tax differentials would be beyond the scope of this study.

The alternative that was adopted, therefore, was to project regional and State personal income for 1980 and 2000 by the following method:

First, comparisons of the annual average rates of changes between GNP and national PY were made.

Average Annual Rates of Change
(percent)

	1950-63	1963-70	1970-75
GNP	3.4	4.0	4.2
PY	3.7	4.3	4.1

During the historical period considered, PY was growing relatively faster than GNP, reflecting relative increases in wages and salaries as percentages of GNP. By 1975, PY and GNP are expected to grow at about the same annual rate, reflecting a balance between wages and salaries and GNP. It is judged that this balance will continue to 1980 and 2000, and since projected PY equals 79.5 percent of GNP in 1975, it can be expected to be equal to 79.5 percent for the low, medium, and high GNP projections in 1980 and 2000.

U.S. Personal Income (PY)
(in billions 1958 dollars)

	1980	2000
Low	838	1,749
Medium	935	2,069
High	962	2,288

By dividing medium national PY of 1980 and 2000 by U.S. medium population projection (excluding armed forces overseas) for 1980 and 2000, national personal income per capita, in 1958 constant dollars, was estimated at $3,994 in 1980 and $6,750 in 2000.

Regional personal income per capita was projected by considering the Nation/region income per capita relationship projected in the NPA study, "State to National Relatives of Per Capita Income (percent) for 1960, 1970, 1975" [4, p.239].

(1) For those States with a converging trend in personal income per capita relative to the national average from 1970-75, the trend was continued at the same annual rate of change until 1980. For example, Montana personal income per capita was projected at 93.1 percent of national personal income per capita in 1970, 93.4 percent in 1975, and 93.7 percent in 1980.

(2) For those States for which the trend was projected to diverge from the national income per capita, the State personal income per capita,relative to the national was assumed to be maintained at the 1975 level until 2000. For example, Colorado personal income per capita relative to national personal income per capita was projected at 106.3 percent in 1970 and 107.7 percent in 1975, remaining at 107.7 percent in 1980.

(3) Between 1980 and 2000, it was assumed that the ratio of each State's personal income per capita relative to the national would change by 50 percent of the difference between the national level and 100 percent. For example, in Wyoming personal income per capita in 1980 was projected at 93.7 percent of national, or 6.3 percentage points below 100. Therefore, in 2000 it was assumed that Wyoming personal income per capita would be 96.9 percent of national, or 3.1 percentage points below 100.

The projected percentages of national personal income projected for each State for 1980 were multiplied by $3,994, and for 2000 by $6,750, the projected national personal income per capita for those years. By multiplying each region's per capita personal income for 1980 and 2000 by the respective medium population projections for 1980 and 2000, a series of regional medium personal income projections were made for 1980 and 2000. To derive a low and high series for personal income by regions for 1980 and 2000, it was assumed that the ratios of the lows and the highs to the medium personal income would be equal to the national ratios for all regions.

Table 80. U.S. Population by Regions, 1948-65
(in thousands)

Region	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
United States[a/].....	146,093	148,666	151,863	154,060	156,472	159,035	161,915	165,064	168,043	171,108	174,057	177,131	179,992	183,057	185,890	188,658	191,372	193,793
Northeast........	38,790	39,551	39,609	39,677	40,135	40,787	41,591	41,986	42,267	42,673	43,373	44,193	44,814	45,434	45,910	46,514	47,075	47,617
North Central....	43,437	44,175	44,645	44,941	45,472	46,379	47,497	48,360	49,163	49,860	50,547	51,147	51,705	52,161	52,537	53,022	53,578	54,089
South............	45,414	45,981	47,268	48,422	48,961	49,172	49,458	50,548	51,533	52,657	53,532	54,324	55,201	56,282	57,398	58,309	59,269	60,106
West:[a/]	18,452	18,959	20,341	21,020	21,904	22,697	23,369	24,170	25,080	25,918	26,605	27,467	28,272	29,180	30,045	30,813	31,450	31,981
Montana........	542	569	598	593	597	608	613	622	646	662	664	667	679	695	696	701	703	703
Idaho..........	551	570	592	587	582	589	589	604	619	639	645	658	671	686	695	689	687	693
Wyoming........	269	277	292	293	297	295	300	315	321	323	322	325	331	336	332	335	338	330
Colorado.......	1,263	1,295	1,337	1,328	1,378	1,454	1,520	1,583	1,655	1,693	1,690	1,727	1,768	1,835	1,883	1,913	1,941	1,949
New Mexico.....	604	644	687	725	747	775	784	808	823	870	904	928	953	959	978	990	1,008	1,014
Arizona........	650	714	756	786	843	895	932	963	1,021	1,113	1,180	1,254	1,321	1,405	1,466	1,517	1,549	1,575
Utah...........	653	671	696	710	730	749	762	798	823	838	855	877	900	936	958	973	977	994
Nevada.........	156	157	162	169	181	196	215	240	250	257	266	279	291	312	347	391	418	434
Washington.....	2,255	2,294	2,386	2,431	2,459	2,485	2,539	2,630	2,689	2,740	2,783	2,823	2,856	2,884	2,944	2,961	2,971	2,973
Oregon.........	1,405	1,431	1,532	1,564	1,595	1,623	1,652	1,690	1,726	1,735	1,735	1,756	1,772	1,788	1,817	1,852	1,886	1,938
California.....	10,064	10,337	10,674	11,159	11,785	12,305	12,738	13,156	13,724	14,235	14,744	15,334	15,862	16,451	16,990	17,556	18,003	18,403

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a/ Excluding Armed Forces overseas; includes Alaska and Hawaii.

Source: [5].

Table 81. U.S. Rural and Urban Populations by Regions, 1950 and 1960

(in thousands)

Region	1950 Total	1950 Rural	1950 Urban	1950 Percent urban	1960 Total	1960 Rural	1960 Urban	1960 Percent urban
United States a/..	151,326	54,479	96,847	64.0	179,323	54,054	125,269	69.9
Northeast......	39,478	8,105	31,373	79.5	44,678	8,838	35,840	80.2
North Central..	44,461	15,970	28,491	64.1	51,619	16,138	35,481	68.7
South.........	47,197	24,241	22,956	48.6	54,973	22,813	32,160	58.5
West: a/	20,190	6,163	14,027	69.5	28,053	6,265	21,788	77.7
Montana......	591	333	258	43.7	674	336	338	50.1
Idaho........	589	336	253	43.0	667	350	317	47.5
Wyoming......	291	146	145	49.8	330	143	187	56.7
Colorado.....	1,325	494	831	62.7	1,754	461	1,293	73.7
New Mexico...	681	339	342	50.2	951	324	627	65.9
Arizona......	750	334	416	55.5	1,302	331	971	74.6
Utah.........	689	239	450	65.3	890	223	667	74.9
Nevada.......	160	68	92	57.5	285	84	201	70.5
Washington...	2,379	876	1,503	63.2	2,853	910	1,943	68.1
Oregon.......	1,521	702	819	53.8	1,769	669	1,100	62.2
California...	10,586	2,047	8,539	80.7	15,717	2,144	13,573	86.4

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a/ Includes Alaska and Hawaii.

Source: [6].

Table 82. National and Regional Labor Force and Employment, 1950 and 1960

(in thousands)

Region	1950 Total labor force	1950 Civilian employment	1960 Total labor force	1960 Civilian employment
United States a/ .	60,329	56,451	69,867	64,638
Northeast.....	16,526	15,449	18,250	17,107
North Central.	17,984	17,226	20,047	18,903
South.........	17,663	16,499	20,398	18,616
West: a/	8,156	7,277	11,172	10,012
Montana.....	232	218	254	231
Idaho.......	218	206	251	233
Wyoming.....	120	108	130	121
Colorado....	513	477	681	626
New Mexico..	230	207	328	288
Arizona.....	265	239	471	430
Utah........	243	229	319	302
Nevada......	71	64	127	112
Washington..	958	840	1,125	1,002
Oregon......	620	577	685	638
California..	4,411	3,902	6,436	5,762

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a/ Includes Alaska and Hawaii.

Source: [5, 6]. Total U.S. Labor force has been subsequently revised, but State-by-State revision does not exist.

Table 83. Summary of National Economic Indicators, 1948-65

Item	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
	Billion 1958 dollars																	
Gross national product..........	323.7	324.1	355.3	383.4	395.1	412.8	407.0	438.0	446.1	452.5	447.3	475.9	487.8	497.3	530.0	550.0	577.6	616.7
Personal consumption expenditures...........	210.8	216.5	230.5	232.8	239.4	250.8	255.7	274.2	281.4	288.2	290.1	303.3	316.1	322.5	338.4	353.3	373.7	398.4
Gross private domestic investment.............	60.4	48.0	69.3	70.0	60.5	61.2	59.4	75.4	74.3	68.8	60.9	73.6	72.4	69.0	79.4	82.3	87.8	98.0
Government purchase of goods and services.....	46.3	53.3	52.8	75.4	92.1	99.8	88.9	85.2	85.3	89.3	94.2	94.7	94.9	100.5	107.5	109.6	111.2	114.3
Exports...........	18.1	18.1	16.3	19.3	18.2	17.8	18.8	20.9	24.2	26.2	23.1	23.8	27.3	28.0	30.0	32.2	36.5	37.5
Imports...........	12.0	11.7	13.6	14.1	15.2	16.7	15.8	17.7	19.1	19.9	20.9	23.5	23.0	22.9	25.5	26.5	27.9	31.5
Personal disposable income......	229.8	230.8	249.6	255.7	263.3	275.4	278.3	296.7	309.3	315.8	318.8	333.0	340.2	350.7	367.3	381.3	406.5	430.8
	1958 dollars																	
Personal disposable income per capita..........	1,567	1,547	1,646	1,657	1,678	1,726	1,714	1,795	1,839	1,844	1,831	1,881	1,883	1,909	1,968	2,013	2,123	2,232
GNP per employee person..........	5,344	5,398	5,787	6,002	6,113	6,304	6,336	6,637	6,603	6,673	6,716	6,985	7,050	7,169	7,499	7,687	7,902	8,234

Source: [12].

Table 84. Federal Reserve Board Industrial Production Indexes, Annual Averages, 1948-65

(1957-59 = 100)

Year	Total industrial product index	Market				Industry				
		Final Products			Materials	Manufacturing			Mining	Utilities
		Total	Consumer goods	Equipment		Total	Durable goods	Nondurable goods		
1948.....	68.4	66.6	58.3	58.3	70.2	68.9	67.0	69.5	84.0	40.8
1949.....	64.7	64.5	52.0	52.0	64.8	65.1	60.9	68.3	74.5	43.4
1950.....	74.9	72.8	56.4	56.4	76.9	75.8	74.1	76.0	83.2	49.5
1951.....	81.3	78.6	78.4	78.4	83.8	81.9	83.5	78.5	91.3	56.4
1952.....	84.3	84.3	94.1	94.1	84.3	85.2	88.5	80.0	90.5	61.2
1953.....	91.3	89.9	100.5	100.5	92.6	92.7	99.9	83.6	92.9	66.8
1954.....	85.8	85.7	88.9	88.9	85.9	86.3	88.4	83.6	90.2	71.8
1955.....	96.6	93.9	95.0	95.0	99.0	97.3	101.9	91.6	99.2	80.2
1956.....	99.9	98.1	103.7	103.7	101.6	100.2	104.0	95.4	104.8	87.9
1957.....	100.7	99.4	104.6	104.6	101.9	100.8	104.0	96.7	104.6	93.9
1958.....	93.7	94.8	91.3	91.3	92.7	93.2	90.3	96.8	95.6	98.1
1959.....	105.6	105.7	104.1	104.1	105.4	106.0	105.6	106.5	99.7	108.0
1960.....	108.7	109.9	107.6	107.6	107.6	108.9	108.5	109.5	101.6	115.6
1961.....	109.7	111.2	112.6	108.3	108.4	109.6	107.0	112.9	102.6	122.3
1962.....	118.3	119.7	119.7	119.6	117.0	118.1	117.9	119.8	105.0	131.4
1963.....	124.3	124.9	125.2	124.2	123.7	124.9	124.5	125.3	107.9	140.0
1964.....	132.3	131.8	131.7	132.0	132.8	133.1	133.5	132.6	101.5	151.3
1965.....	143.4	142.5	140.3	147.0	144.2	145.0	148.4	140.8	114.8	160.9

Source: [2].

Table 85. National and Regional Gross Product Originating by Sector
1947, 1957, 1960 and 1962

(in millions of 1958 dollars)

Region	1947				1957				1960				1962			
	Total	Agri-cult-ure	Manu-fact-uring	Other	Total	Agri-cult-ure	Manu-fact-uring	Other	Total	Agri-cult-ure	Manu-fact-uring	Other	Total	Agri-cult-ure	Manu-fact-uring	Other
United States[a/]....	301,761	30,651	87,792	183,318	451,595	24,652	135,664	291,279	484,482	23,334	138,583	322,565	533,246	22,941	151,916	358,389
Northeast........	90,851	2,343	31,991	56,517	127,378	1,999	42,613	82,766	137,851	1,966	45,927	89,958	150,011	1,575	49,464	98,972
North Central....	95,919	12,774	31,908	51,237	140,613	10,631	49,895	80,087	143,660	8,231	48,188	87,241	155,741	8,737	51,718	95,286
South............	71,132	10,170	16,005	44,957	111,416	7,272	26,937	77,207	121,819	8,687	26,766	86,366	135,916	8,353	30,401	97,162
West:[a/]	43,859	5,364	7,888	30,607	72,188	4,750	16,219	51,219	81,152	4,450	17,702	59,000	91,578	4,276	20,333	66,969
Montana........	1,215	412	118	685	1,712	363	199	1,150	1,640	238	169	1,233	1,863	314	196	1,353
Idaho..........	1,067	348	133	586	1,367	305	193	869	1,469	235	236	998	1,653	237	263	1,153
Wyoming........	705	150	53	502	1,057	118	86	853	955	94	67	794	999	88	71	840
Colorado.......	2,603	566	337	1,700	4,256	318	644	3,294	4,782	288	734	3,760	5,362	234	856	4,272
New Mexico.....	960	177	49	734	2,113	134	128	1,851	2,217	158	137	1,922	2,381	148	155	2,078
Arizona........	1,218	180	96	942	2,588	297	303	1,988	3,248	265	406	2,577	3,794	265	493	3,036
Utah...........	1,255	173	162	920	2,051	126	355	1,570	2,236	90	388	1,758	2,603	91	482	2,030
Nevada.........	401	44	21	336	879	37	75	767	947	28	44	875	1,242	26	54	1,162
Washington.....	5,103	678	1,122	3,303	7,171	502	1,867	4,802	7,656	429	1,930	5,297	8,686	417	2,282	5,987
Oregon.........	3,162	427	852	1,883	4,049	347	998	2,704	4,686	298	1,205	3,183	5,114	277	1,288	3,549
California.....	26,170	2,209	4,945	19,016	44,945	2,203	11,371	31,371	48,900	2,181	12,169	34,550	55,257	2,052	13,942	39,263

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a/ Includes Alaska and Hawaii.

Source: [2].

Table 86. Regional Personal Income, 1948-65

(in millions of 1958 dollars)

Region	1948	1950	1955	1960	1965
United States[a/]..	252,889	272,819	327,982	389,802	488,631
Northeast......	76,255	82,523	96,301	111,726	134,531
North Central..	81,094	85,162	101,596	114,857	142,979
South.........	58,448	64,296	77,801	93,706	122,960
West:[a/]	37,092	40,838	52,284	69,513	88,161
Montana......	1,051	1,154	1,250	1,330	1,560
Idaho........	857	913	964	1,171	1,560
Wyoming......	508	572	590	753	735
Colorado.....	2,138	2,328	2,941	4,965	4,870
New Mexico...	789	1,076	1,222	1,682	2,020
Arizona......	1,041	1,181	1,711	2,576	3,398
Utah.........	967	963	1,334	1,663	2,112
Nevada.......	332	379	616	796	1,286
Washington...	4,385	4,808	5,581	6,440	7,900
Oregon.......	2,747	2,957	3,330	3,893	4,960
California...	21,396	23,676	31,725	42,231	55,098

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a/ Includes Alaska and Hawaii.

Source: [12].

Table 87. National and Regional Urban Populations as Percentages of Total National and Regional Populations, 1980 and 2000

Region	1960 (Actual)	1980	2000
United States[a]...	69.9	77.2	82.0
Northeast......	80.2	82.4	84.5
North Central..	68.7	75.5	80.9
South..........	58.5	70.1	77.1
West:			
Montana......	50.1	60.0	67.0
Idaho........	47.5	57.1	62.6
Wyoming......	56.7	66.2	75.2
Colorado.....	73.7	85.1	89.9
New Mexico...	65.9	83.2	90.5
Arizona......	74.6	86.2	88.7
Utah.........	74.9	82.1	85.1
Nevada.......	70.5	84.8	91.5
Washington...	68.1	75.8	81.9
Oregon.......	62.2	71.7	78.3
California...	86.4	89.8	91.3

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a/ Includes Alaska and Hawaii.

Source: [5] and unpublished data, Bureau of Public Roads, 1965.

APPENDIX TO CHAPTER III

AGRICULTURAL COMMODITIES AND FORAGES

Historical Time Series of Domestic Consumption and Exports of Food, Feed, Forage, and Fiber Commodity Groups

Tables 88 through 93 in this Appendix summarize annual historical consumption statistics from 1948 through 1965 for the agricultural commodities and forages projected in Chapter III. Except for minor differences in the classifications of end uses which were made in order to refine projection techniques, these series are compatible with the equivalent historical tables in Resources In America's Future. Differences in consumption reported since 1955 reflect revisions published subsequent to 1961. Significant changes in earlier data were made by the U.S. Departments of Agriculture and Commerce, following their analyses of the Census of Agriculture (1959 and 1964) and Census of Manufactures (1963).

Analytical Procedures Used

The multiple regression equations used to project domestic consumption of agricultural commodities and forages are identified in tables 96, 97, 99, and 101 of this Appendix. These equations represent the "best" solutions of hundreds of sets of statistical relationships developed by a step-wise multiple regression program.

The selection procedure for choosing these particular equations considered many criteria. The percentage of variation in consumption during the 1948-65 period which was explained by the regression equation, and the economic logic which should be attached to the mathematical sign of each net regression coefficient, were of considerable relevance. However, the statistical reliabilities which were estimated regarding the magnitude of these coefficients, or the relative importance of the various explanatory factors and verification of their respective mathematical signs, were equally important. Finally, an equation was not used for projecting consumption if statistical tests of the Durbin-Watson statistic indicated that residuals (differences between actual and calculated results) were serially correlated.

With very few exceptions, the coefficients of determination (R^2) of the equation(s) used indicated that well over 90 percent of the annual variation in historical consumption was explained by these models. The mathematical sign of each regression coefficient, or the "combined effect" of the signs of several different transformations of the same factor in a given equation, seem consistently logical and acceptable, except in the case of per capita consumption of cotton for all purposes. Furthermore, appropriate statistical tests confirmed that nearly all these coefficients were significantly different from zero at the 95-percent level of probability.

Multicollinearity, or interdependence between independent variables, was minimized by proper and complete specification of models of economic determinants of consumption. Except for equations concerning cotton, correlation between independent variables did not distort equation solutions sufficiently to reverse logical signs of regression coefficients. High intercorrelations between time, income, and general price level were apparent during 1948-65, but these relationships did not disturb the solutions sufficiently to prevent most important explanatory variables from being included in multiple regression equations, except in certain cases involving food commodities (wheat and meats) and cotton fiber. Most of these variables should continue to be related in much the same manner during the next 30 years, according to the projections in Chapter II of this report. Under such stipulations, distortions because of multicollinearity should be negligible.

Projections were based on the predetermined or estimated values of the appropriate demographic and economic variables presented in Chapter II of this report and on the values of additional explanatory factors summarized in tables 94, 95, 98, and 100 of this Appendix. The subjective appraisals and statistical analyses leading to the final selection of most of the values actually assigned to many of these predetermined variables cannot be described briefly. All appear consistent with the projections contained elsewhere in this report, and with contemporary authoritative statements pertaining to price relationships and technological developments which would significantly alter historical patterns of consumption.

For each consumption variable, then, one or more satisfactory complementary regression equation was used to make domestic consumption projections for 1980 and 2000. The procedures followed in translating the mathematical solutions of these several equations into probable levels of total demand for each commodity varied somewhat. Generally speaking, only moderate subjective modifications of the consumption levels predicted by the regression equations seemed either necessary or appropriate. The outcome projected was normally weighted by each equation in proportion to the average statistical reliabilities of the various regression coefficients. For wheat and lamb projections, however, conclusions which would have been drawn from these regression coefficients strongly implied that recent declining consumption patterns would be reversed in the near future. Thus, the projections are not in complete agreement with solutions for these particular regression equations.

Procedures Used to Project Exports of Grains and Soybeans

The preparation of plausible export projections required a distinctly different methodological approach. First, the development of precise mathematical explanations of how and why exports varied during the years 1948-65 did not appear particularly useful. Traditional patterns of world trade in grains and, more specifically, the U.S. share of this trade, were changed by the enactment of the original Food for Peace Act (Public Law 480) in 1954 and subsequently by the huge commercial import demand generated by rapidly rising personal incomes in both Western Europe and Japan. Furthermore, significant new changes in the structure of the international trade in grains seem imminent, partly as a result of new legislation passed in 1966 (Food for Peace Act) and new agreements concerning international grain trade. Many export determinants cannot be quantified. Some time series of appropriate variables are available, but most of the empirical data are limited to cross-sectional estimates, such as per capita income elasticities of demand for all foods in a given economy. Rather than rely heavily on such parameters, more formal methods of projecting exports were selected. First, trends of exports since 1954 were estimated relative to time, import demands in prime commercial markets, and population and nutritional problems of developing countries. Second, contemporary projections of probable U.S. export levels through 1985 were used to develop several modified, different rates of growth for exports which are likely to be achieved by 1980 and 2000. These different levels of U.S. foreign trade in grains are the ones which were considered most likely, under a wide range of circumstances which are explicitly stated. Such informal techniques are both plausible and defensible, and a number of apparently unlike assumptions, when combined in different ways, can produce very similar projections.

The most significant determinants of trends in commercial sales of U.S. grains abroad will continue to be population and income or foreign exchange earnings (or reserves) of our traditional trading partners. Concessional sales of food grains will be determined by U.S. foreign policies towards free world developing nations and food grain balances in these countries. While all projections assume that the economies of these countries will grow faster than populations on balance, different assumptions were made concerning the capabilities of individual nations to increase per capita food consumption while maintaining a satisfactory balance between agricultural production, food consumption, and total economic growth. Rapid growth in food production could permit increased per capita consumption of calories and would permit imports of food commodities to be decreased. In contrast, a rapid increase in gross domestic product accompanied by a moderate increase in agricultural production would increase food import requirements immensely. Unless or until these nations acquire sizable foreign exchange reserves, food imports will continue to consist largely of donations or concessional sales, since available foreign exchange undoubtedly will be needed to finance economic development of both agricultural and nonagricultural sectors.

All projections of grain exports presented in table 24 of Chapter III are based on several implicit, nonquantifiable assumptions. Trade between free world and Communist countries in these commodities will not exceed the proportional shares of world trade attained in 1960-64, and the U.S.S.R. should become a net grain exporter before 1980, but most of this shipment will be to other communist countries. U.S. foreign policies concerning food aid and promotion of economic development in free world nations will continue, consistent with the assumption that Food for Peace legislation as amended in 1966 will become permanent. Actual food aid shipments will not exceed 1963-65 levels under most circumstances or equivalent percentages of government expenditures under other stipulations. However, multilateral food aid programs and the net flow of capital from developed nations to less developed countries should increase significantly, at least to 1980 and probably through the 1980's, regardless of aggregate balances achieved between agricultural production and food consumption in Latin America, Africa, and Southern Asia. No major shifts in patterns of world trade in these commodities should occur which would alter significantly recent U.S. shares of important feed grain and soybean markets. In the case of wheat, gradual loss of commercial markets should be more than balanced by growth in shipments under aid programs or sales financed by favorable credit terms. Large interregional shifts in distribution of U.S. wheat shipments should be anticipated.

Differences in levels of grain export projections reflect different explicit assumptions concerning growth rates of domestic product (agricultural and total) and population abroad. Dissimilarities between estimated propensities of importing nations to buy U.S. agricultural products as their incomes rise explain much of the range in projections in both 1980 and 2000.

Similar factors explain the comparatively wide range of exports projected for soybeans. Low projections of foreign sales of U.S. soybeans assume that exports will grow at a rate corresponding to increases in commercial feed grain sales to Western Europe and Japan. The real possibilities for much larger exports in 1980 and 2000 imply corresponding expansion of foreign oilseed processing capacity. Finally, domestic supplies of U.S. soybeans are assumed to be ample and to be offered on world markets at prices fully competitive with other oilseeds and sources of vegetable proteins.

Projections of Exports of Raw Cotton

Important assumptions concerning alternate U.S. agricultural policies dominate all other factors which should determine levels of cotton exports during the next 30 years. Low projections (table 27 of Chapter III) are consistent with the assumption that lower domestic cotton prices will limit acreage and production so that only residual quantities not required by U.S. mills are offered for commercial foreign sales. Modest shifts in both demand and supply schedules during the 1980's and 1990's explain the increase in low projections between 1980 and 2000. High projections for 1980 assume that U.S. exports will supply the cotton needed to balance total production and consumption in all other countries, and that foreign consumption will be encouraged and free world foreign production actively discouraged by U.S. policy. This policy would be to offer to sell cotton at sufficiently low prices in quantities necessary to acquire a much larger share of world trade in raw cotton than U.S. commercial exports have attained since the early 1950's. The medium projection implies a similar U.S. policy, except that U.S. exports would only balance foreign free world production and consumption (no East-West trade in raw cotton or manufactures is assumed). Again, lower world cotton prices are stipulated, if world trade in cotton is to become large enough for U.S. exports to reach levels projected.

Projections of high and medium cotton exports in 2000 are consistent with similar stipulations. World cotton trade and U.S. exports are assumed to increase at the constant percentage(s) change each year as the average during 1980-2000, as was projected for the 1970's under similar circumstances.

Table 88. U.S. Wheat: Domestic Consumption, Total and for Food and Exports, 1948-65

(Million bushels)

Year a/	Domestic consumption		Exports d/
	Total disappearance b/	Used as food c/	
1948......	594.7	489.2	504.0
1949......	604.4	492.9	299.1
1950......	602.2	493.2	366.1
1951......	599.8	496.5	475.3
1952......	571.1	488.2	317.8
1953......	564.0	487.2	217.0
1954......	546.2	485.9	274.0
1955......	535.4	481.6	346.3
1956......	530.3	482.4	549.5
1957......	528.4	486.1	402.9
1958......	544.1	497.1	443.3
1959......	534.0	497.3	509.8
1960......	541.0	497.2	661.5
1961......	551.6	501.1	719.4
1962......	593.3	500.4	643.8
1963......	523.4	503.3	856.1
1964......	578.0	509.2	725.0
1965......	669.3	515.1	867.4

---

a/ Year beginning July 1.

b/ Includes wheat fed, small industrial use (alcoholic beverage), and seed requirements. The last varied from 95.0 to 61.4, depending largely upon acreage.

c/ Includes use by military at home and abroad.

d/ Includes wheat equivalent of flour and other wheat products exported.

Source: [9, 20].

Table 89. Feed Grains: Quantities Fed to Livestock and Poultry in the United States and U.S. Exports, 1948-65

(in millions)

Year a/	Quantity fed in U.S.		Exports (four grains) c/
	Six grains b/	Corn only	
	Feed units	Tons	Tons
1948.......	92.5	66.5	5.67
1949.......	98.5	74.5	4.52
1950.......	100.7	73.1	6.61
1951.......	102.5	75.2	4.92
1952.......	92.1	67.7	5.08
1953.......	93.7	69.7	3.92
1954.......	93.2	65.9	6.08
1955.......	98.4	69.4	8.07
1956.......	96.2	69.9	7.34
1957.......	103.1	73.5	10.50
1958.......	111.9	80.5	12.80
1959.......	117.3	87.9	12.19
1960.......	131.2	89.0	12.31
1961.......	129.4	91.9	17.58
1962.......	123.8	90.3	16.55
1963.......	120.2	86.2	18.75
1964.......	117.3	84.4	21.90
1965.......	130.0	95.4	29.09

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a/ Year beginning October 1.

b/ Corn, barley, oats, rye, sorghum grain, and wheat.

c/ Corn, barley, oats, sorghum grain.

Source: Six grains and corn from [6, 15], includes corn grains in corn silage. None of this data from 1959-65 reflects revisions based on the 1964 Census of Agriculture or 1963 Census of Manufactures. Exports from [8].

Table 90. Soybeans: Quantities Processed by U.S. Oilseed Mills, and U.S. Exports, 1948-65

(million bushels)

Year a/	Processed by domestic mills	Exported	Total disappearance b/
1948........	183.7	23.0	226.6
1949........	195.3	13.1	234.5
1950........	252.0	27.9	298.0
1951........	244.4	17.0	284.4
1952........	234.4	31.9	292.3
1953........	213.2	39.7	278.0
1954........	249.0	60.6	332.4
1955........	283.1	67.0	379.4
1956........	316.0	85.7	443.5
1957........	353.8	86.0	472.7
1958........	401.2	110.3	539.4
1959........	393.4	141.6	572.0
1960........	402.2	130.1	572.6
1961........	438.8	153.2	639.6
1962........	474.5	180.3	703.1
1963........	440.9	191.1	686.1
1964........	473.2	205.9	727.5
1965........	537.5	250.6	839.6

---

a/ Crop year beginning October 1.

b/ Includes seed use and unallocated loss or waste (residual). Seed use varied from 15.9 to 42.4 million, according to acreage.

Source: [7, 18]. Data adjusted to October-September year whenever necessary.

Table 91. Salient Statistics Concerning Forage and Meat Consumption in the United States, 1948-65

(in millions)

Year	Livestock numbers and forage consumption[a]					Total consumption of selected meats[a,b]		
	Roughage-consuming animal units	Feed nutrients obtained from forages						
		Pasture and grazing		Harvested forage				
		Total	Per animal unit	Total	Per animal unit	Beef	Veal	Lamb and mutton
		Tons of feed units, corn equivalent				Pounds, carcass wt. equiv.		
1948..	82.1	93.4	1.13	48.3	.57	9,163	1,384	733
1949..	82.4	94.2	1.10	51.6	.59	9,439	1,310	609
1950..	85.6	99.8	1.11	54.8	.60	9,529	1,206	596
1951..	90.2	101.2	1.07	57.4	.61	8,472	1,003	517
1952..	94.6	102.9	1.08	59.1	.61	9,548	1,099	640
1953..	95.7	103.0	1.07	60.1	.62	12,113	1,485	735
1954..	96.2	107.4	1.13	62.3	.62	12,743	1,591	730
1955..	95.2	102.1	1.11	60.5	.65	13,313	1,531	753
1956..	91.9	114.1	1.26	63.4	.66	14,121	1,572	735
1957..	90.5	117.8	1.27	65.4	.70	14,242	1,481	709
1958..	92.5	112.7	1.19	65.4	.71	13,786	1,150	719
1959..	94.7	118.6	1.24	66.7	.69	14,202	990	830
1960..	95.7	121.0	1.24	68.6	.70	15,122	1,093	852
1961..	97.6	119.8	1.19	68.5	.70	15,875	1,021	923
1962..	100.6	121.9	1.18	70.3	.68	16,300	1,003	949
1963..	103.3	126.7	1.22	70.4	.69	17,577	913	908
1964..	103.9	134.8	1.30	70.9	.68	18,879	990	795
1965..	103.5	131.6	1.28	70.9	.69	19,032	992	716

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a/ Livestock numbers are based on years beginning May, forage use on years beginning October, and meat consumption on calendar years. Data include only the 48 conterminous States.

b/ By U.S. civilians.

Source: Data from [6, 12, 15].

Table 92. Food and Industrial Uses of Grains Other Than Wheat and Rice, U.S. Consumption by Principal End Use or Industry, 1948-65

Year[a]	Corn grindings by wet-processing industry	Cornmeal	Breakfast foods	Alcoholic beverages	
				Fermented malt liquors	Alcohol and distilled spirits
	Thous. bushels	Thousand tons			
1948........	109,878	938.4	461.9	2,635.7	1,390.5
1949........	116,174	947.3	469.9	2,631.2	1,125.9
1950........	131,439	895.0	470.2	2,628.3	2,942.6
1951........	129,049	833.1	486.0	2,650.6	1,524.0
1952........	126,128	816.1	486.5	2,695.5	650.1
1953........	130,345	781.8	486.7	2,773.7	939.5
1954........	130,940	755.1	487.2	2,627.1	927.1
1955........	137,913	719.0	495.8	2,608.2	1,145.1
1956........	141,373	698.1	504.7	2,644.9	1,137.7
1957........	139,391	676.5	522.4	2,625.2	1,112.5
1958........	144,078	644.3	557.2	2,698.7	1,279.6
1959........	153,011	619.8	566.6	2,797.6	1,352.6
1960........	153,471	596.3	596.3	2,751.6	1,268.9
1961........	157,125	578.8	606.4	2,629.6	1,444.1
1962........	171,374	569.3	634.6	2,922.0	1,080.4
1963........	184,933	577.7	653.5	3,110.8	1,045.5
1964........	193,863	557.1	662.8	3,254.5	1,073.5
1965........	204,916	554.6	671.3	3,285.8	1,230.0

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a/ Calendar year except for uses for alcoholic beverages, which are by fiscal years beginning July 1 of each year.

Source: Data from [3, 8, 9]. Alcoholic beverages calculated by Robert R. Nathan Associates from basic data.

Table 93. Cotton: U.S. Domestic Consumption of Cotton Fiber, with Comparisons, and U.S. Exports of Raw Cotton, 1948-65

Year[a]	Total domestic consumption			Per capita Domestic consumption		Exports
	All uses	Apparel products	Other uses	Cotton	All fibers[b]	
	--------Million pounds-------			------Pounds--		Mil.lbs.
1948......	4,025.7	n.a.	--	27.5	41.4	2,486.5
1949......	3,472.6	1,349	2,123.6	23.3	35.1	3,002.0
1950......	4,464.1	1,462	3,002.1	29.4	45.6	2,104.0
1951......	4,513.9	1,417	3,096.9	29.3	44.1	2,855.5
1952......	4,165.1	1,542	2,623.1	26.5	41.5	1,590.5
1953......	4,209.4	1,648	2,561.4	26.4	41.5	1,957.0
1954......	3,885.6	1,608	2,277.6	23.9	38.3	1,792.5
1955......	4,206.6	1,759	2,447.6	25.4	43.5	1,160.0
1956......	4,216.0	1,701	2,515.0	25.1	41.6	3,958.0
1957......	3,878.0	1,672	2,206.0	22.6	39.3	2,979.5
1958......	3,729.0	1,677	2,052.0	21.4	37.6	1,447.5
1959......	4,274.4	1,824	2,450.4	24.1	43.4	3,696.0
1960......	4,232.8	1,769	2,463.8	23.4	40.7	3,428.5
1961......	4,048.5	1,789	2,259.5	22.0	40.4	2,457.5
1962......	4,277.5	1,871	2,406.5	22.9	44.0	1,675.5
1963......	4,136.7	1,855	2,281.7	21.8	45.4	2,831.0
1964......	4,331.3	1,943	2,388.3	22.5	48.6	2,030.0
1965......	4,664.3	n.a.	--	24.0	54.1	1,471.0

a/ Calendar year except for exports, which are summarized by crop year beginning August 1.
b/ Expressed in cotton equivalent pounds.

Source: Data from [16, 21]. Other uses and exports calculated or converted by Robert R. Nathan Associates from basic data.

Table 94. Selected Economic Determinants for Quantities of Grains Fed and Soybeans Processed in the United States, 1965 and Estimated Values for 1980 and 2000

Commodity and predetermined factor (independent variable)	1965 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Total grain							
Livestock prices/feed grain and hay prices; ratio of index numbers....................	87.9	90.1	100.7	114.7	90.1	103.4	123.8
Personal consumption expenditures times (retail price index for all food items divided by livestock price index)........	437.0	888.3	966.2	862.7	2,025	2,170	1,926.2
Total high protein feeds fed/all concentrates fed; ratio of quantities expressed in feed units..........................	0.1873	0.201	0.198	0.195	0.207	0.205	0.203
Total feed concentrates fed per grain-consuming livestock production unit.......	0.74	0.68	0.70	0.795	0.69	0.71	0.9325
Price of high protein feeds/price of all feeds purchased; ratio of index numbers...	129.2	120	132	151	120	139	180
Corn							
High protein feeds fed per grain-consuming animal unit, tons.....................	0.11045	0.14352	0.14648	0.14865	0.209119	0.213433	0.220887
Tons of high protein feeds fed/tons of all concentrates fed; ratio of actual weights.................................	0.11555	0.127	0.123	0.120	0.1349	0.1265	0.123
Corn prices/price index of feed grains.....	106.4	107.6	102.1	97.0	107.6	99.8	97.0
Livestock prices/feed grain and hay prices; first difference of ratios of index numbers................................	+13.8	+5.0	+1.9	-1.0	+5.0	+1.9	-1.0
Soybeans							
FRB Index for Food Manufacturers..........	122.3	167.5	173.6	175.6	212.9	224.8	231.9
Livestock prices/feed grain prices; ratio of index numbers.........................	89.8	93.0	103.0	115.8	93.0	116.0	125.0
Livestock prices/feed grain prices; first difference of ratio of index number......	+13.4	+1.7	+3.29	+5.0	+1.7	+3.29	+5.0

Source: 1965 data -- Price indexes from [3]; feed consumption and pasture and range condition data from [8] or from [6, 15]; FRB indexes; and calculations of all ratios and first differences by Robert R. Nathan Associates.

Factor projected and predetermined factor (independent variable)	1965 (actual or lagged)	1980			2000		
		Low	Medium	High	Low	Medium	High
Roughage-consuming animal units							
Livestock prices/retail prices of all foods; ratio of Index number lagged 2 years..................	84.7	79.8	80	92.2	67.2	74.0	92.2
Pasture used/animal unit							
Personal disposable income per capita times the ratio retail price index for all foods/ livestock price index...............	2,448.3	3,997.4	4,565	4,209.3	7,329.8	7,854.0	6,971.8
Pasture and range condition, season following winter feeding, index number.....................	77.6	72.9	77	81.1	71.9	76	86
Hay prices deflated by--							
Feed grain and hay price index[a].	-0.6	-2.35735	+0.46111	+3.27957	same as 1980		
Purchased feeds price index[a]....	-1.1	-2.81846	+0.24444	+0.46111	same as 1980		
Pasture used/animal unit and harvested roughage fed/animal unit							
Livestock price index[a]............	-4.0	+3.458346	+0.20556	-3.04722[b]	same as 1980		
Harvested roughage fed/animal unit							
High protein feeds fed per high-protein-consuming animal unit,lbs.	230	305.03	312.8	314.1	444.4	474.0	476.0
Pasture and range conditions[d].....	+4.6	0.00	-0.11667	+4.12490	same as 1980		
Livestock prices/feed grain and hay prices[b].........................	+0.004	-4.38433	+0.71567	+5.81567	same as 1980		

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[a] First difference of ratio.
[b] 0.000 used for invested roughage projection.
[c] First difference of index numbers.
[d] First difference of ratio of lagged values of index numbers.

Source: 1965 data from [3, 6, 8, 15]. Calculations of all ratios and first differences by Robert R. Nathan Associates.

Table 96. Statistical Relationships Between Selected Independent Variables and Quantities of Grains Fed to Livestock and Poultry in the U.S., and Quantities of Soybeans Processed Domestically, annually, 1948-65

All grains fed to livestock and poultry	Percent of variation explained
$X_1^* = 13.71 + 0.00012(X_2)^2 + 153.29142(X_3)^2 + 0.00148(X_4)^2$ D.W. statistic indicates residuals are not serially correlated	95.3
$X_1^* = 285.283 - 27{,}279.71704(\frac{1}{X_2}) - 793.58470X_5 + 0.33464X_4 + 0.24399X_6$ D.W. statistic indicates residuals are not serially correlated	97.3
Corn fed to livestock and poultry	
$X_7^* = 95.95 + 1217.84729X_8 - 1152.68419X_9 - 0.15046X_{10}$ D.W. statistic indicates residuals are not serially correlated	97.1
$\frac{1}{X_7} = .00649 - 0.17730X_8 + 0.15303X_9 + 0.00002^{\#}X_{10} + 0.00005X_{11}$	97.2

Description of variables

X_1 = All grains fed, in millions of tons of feed units (corn equivalent)

X_2 = Personal consumption expenditures in billion 1958 dollars times [consumer price index all food commodities (1957-59 = 100) divided by price index for livestock (1957-59 = 100), this ratio times 100][a]

X_3 = Total concentrates fed per livestock production unit based on concentrates, tons.

X_4 = Ratio of index of livestock and product prices to feed grains and hay prices, multiplied by 100. Both indexes, 1957-59 = 100 lagged 1 year.

X_5 = High protein feeds fed/total feed concentrates fed, with both feeds expressed in feed units

X_6 = Ratio of index of prices of high protein feeds to all purchased feeds, multipled by 100. Both indexes (1957-59 = 100).

X_7 = Corn fed, in millions of tons.

X_8 = High protein feeds fed per grain consuming animal unit, tons.

Continued--

Table 96. Statistical Relationships Between Selected Independent Variables and Quantities of Grains Fed to Livestock and Poultry in the U.S., and Quantities of Soybeans Processed Domestically, annually, 1948-65, continued--

Soybeans process by U.S. oilseed mills	Percent of variation explained
$X_{12}^* = -417.18 + 6.62142X_{13} + 0.01233(X_{14})^2 + 1.29930X_{15}$	97.1
$X_{12}^* = -1600.41 + 372.38425(\mathrm{Log}_{10} X_{13})^2 + 121.30217(\mathrm{Log}_{10} X_{14})^2$ D.W. statistic indicates residuals are not serially correlated.	97.0

Description of variables

X_9 = Ratio of high protein feeds fed to all feed concentrates, by weight.

X_{10} = First difference: X_4 this year minus X_4 last year.

X_{11} = Ratio of average price received by farmers for corn to index of prices of all feed grains (1957-59 = 100), times 100, ¢bu., lagged 1 year.

X_{12} = Soybeans processed, millions of bushels, crop year beginning October 1.

X_{13} = FRB index for foot manufacturers (1957-59 = 100), not seasonally adjusted, lagged 1 year.

X_{14} = Ratio of index of livestock prices to feed grain prices, multiplied by 100, last feeding year.

X_{15} = First difference: X_{14} current year minus X_{14} last year.

Statistical significance of Regression Coefficients:

*Indicates that all regression coefficients in this equation are significantly different from zero, statistically speaking, at 95 percent level of probability.

#Indicates that this particular regression coefficient is not significant, in the above sense. (All other regression coefficients not so marked are significant).

a/ In second equation, this variable is PCE in billion 1958 dollars.

Table 97. Statistical Relationships Between Selected Independent Variables and Roughage-Consuming Animal Unit Numbers and Forage Consumption per Animal Unit, 1948-65

Roughage-consuming animal units fed annually	Percent of variation explained
$X_1 = 461.76187 - 0.56253X_2 - 11770.52686\ (1/X_2) - 19{,}010.35156\ (1/X_3) - 0.74873X_4 - 4{,}802.14215\ (1/X_4) - 0.06506\ X_5$	94.7
$X_1^* = 381.55 - 0.4431\ X_2 - 8{,}955.2981\ (1/X_2) - 1.04366\ X_4 - 7{,}992.88904\ (1/X_4) + 0.10598\ X_6$	90.0
DW statistic indicates residuals are not serially correlated	
Pasture used/animal unit	
$10\ \mathrm{Log}_{10}\ X_7^* = 0.02668 + 0.03726\ (\mathrm{Log}_{10}\ X_8)^2 + 0.18180\ (\mathrm{Log}_{10}\ X_9) + 0.00219\ X_{10}$	98.2
$10X_7^* = 15.03939 + 0.96757\ (\mathrm{Log}_{10}\ X_8)^2 = 4.64534\ (\mathrm{Log}_{10}\ X_9)^2 + 0.10844\ X_{11} - 0.04507\ X_{12}$	97.8
DW statistic indicates residuals are not serially correlated	
$10X_7^* = 4.73530 + 0.00162\ X_8 + 0.00068\ (X_9)^2 + 0.06794\ X_{10} - 0.00549\ (X_{10})^2$	98.4
DW statistic indicates residuals are not serially correlated	

Description of variables

X_1 = Roughage-consuming animal units, millions, Year beginning May 1

X_2 = Ratio of indexes of livestock and livestock prices to CPI All Food Commodities, times 100, lagged 2 years. Both indexes, 1957-59 = 100

X_3 = Personal consumption expenditures, billions of 1958 $

X_4 = X_{14}' Table III-9, lagged 2 years

X_5 = X_{14}' Table III-9, lagged 1 year

X_6 = X_2' Table III-9

X_7 = Pasture/used animal unit, in millions of feed units (tons) Year beginning October 1

X_8 = Personal disposable income per capita, 1958 dollars, times (consumer price index all food commodities (1957-59 = 100) divided by price index for livestock (1957-59 = 100, this ratio times 100)

X_9 = USDA's Index of Pasture and Range conditions for season following winter of feeding year beginning October 1

Continued--

Table 97. Statistical Relationships Between Selected Independent Variables and Roughage-Consuming Animal Unit Numbers and Forage Consumption per Animal Unit, 1948-65

continued--

Roughage-consuming animal units fed annually	Percent of variation explained
Harvested forage fed/animal unit	
$1/X_{13}^{*} = 0.81975 + 136.74088\ (1/X_{14}) - 0.00167\ X_{15}$	95.0
$\text{Log } X_{13}^{*} = 1.17180 + 0.00029\ (X_{16})^2 - 0.00054\ (X_{12})^2 + 0.43203\ \text{Log}_{10} X_{14}$	96.0

Description of Variables

X_{10} = Average price of hay, U.S., July-June average, \$/ton, deflated by price index for feed grains and hay (1957-59 = 100), and multiplied by 100; first difference of this ratio

X_{11} = Same hay prices as used in X_{10}, but deflated by equivalent index of prices paid by farmers for all feed purchased, and multiplied by 100; first difference of this ratio

X_{12} = Same hay prices as used in X_{10}, but deflated by equivalent index of livestock prices, and multiplied by 100; first difference in this ratio

X_{13} = Harvested roughage fed/animal unit, tons of feed units.

X_{14} = High-protein feeds per high-protein consuming animal unit, pounds per animal

X_{15} = X_4 (table 96), first difference between values of prior 1 and 2 years

X_{16} = First difference, X_9 above

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* Indicates that all regression coefficients in this equation are statistically different from zero, at 95 percent level of probability.

Table 98. Selected Economic Determinants of Domestic Per Capita Consumption of Meats and Certain Consumption of Grains for Food and Industrial Purposes, 1965 and Estimated Values for 1980 and 2000

Commodity or end-use and predetermined factor (independent variable)	1965 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
Beef							
Retail beef price deflated, ¢/lb...	75.0	104.2	98.3	90.5	135.3	104.2	98.3
Corn Processed by Wet-milling industry							
Corn oil price, crude, Decatur, deflated by index of prices received by farmers for oil-bearing crops, ¢/lb...............	14.1	11.3	11.0	10.3	11.3	9.8	9.5
All grains used to make fermented malt liquors							
Personal consumption expenditures for alcoholic beverages per capita, deflated[a]........................	59.75	67	77.5	81.5	78	94	112
Wholesale price index for alcoholic beverages, deflated by CPI for all items (1957-59 = 100).............	93.15	98	93	90	94	82	73
Lamb and Mutton							
Lamb price, retail, deflated, ¢/lb.[a]	73.1	95.9	88.5	80	99.8	93.7	83.5
Lamb-beef price ratio at retail....	.975	.92	.90	.884	.92	.884	.74
Veal							
Veal price, retail, deflated, ¢/lb[a]	76.1	107.4	85.7	84.0	--------Not calculated---		
Veal-beef price ratio at retail....	1.015	1.031	.974	.947	--------Not calculated---		
Wheat							
Average wheat price received by farmers deflated[a] and adjusted for certificates purchased by domestic flour millers, ¢/lb......	213.4	262	224	192	292	264	232

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[a] These prices were deflated by consumer price index for all food commodities (1957-59 = 100).

Source: 1965 data -- Retail meat prices [13]; corn oil prices [18]; alcoholic beverages [17]; price indexes [21]; and wheat prices [3].

Table 99. Relationships Between Selected Independent Variables and Domestic Consumption of Indicated Meats and Uses of Grains for Food and Alcoholic Beverages, 1948-65

	Percent of variation explained
Per capita beef consumption	
$X_1^* = -315.62 + 0.13966X_2 + 6.28156X_3 - 0.00002(X_2)^2 - 0.04378(X_3)^2$ D.W. statistic indicates that residuals are not serially correlated	99.1
$X_1^* = -536.41 + 227.89775 \text{ Log}_{10}X_2 - 35.25928 (\text{Log}_{10}X_3)^2$	96.7
Total corn consumed by wet-milling industry	
$X_4^* = 46{,}330.3 + 1{,}224.33707X_5 - 1{,}839.95016X_6$ Add to constant the sum 20,770.1 when using for any year after 1960.	99.1
$\text{Log } X_4^* = 5.52013 - 35{,}59617(\frac{1}{X_5}) + 0.00048X_6$	96.2
$X_4^* = 35{,}862.14 + 1{,}202.57971X_5 + 183.48873X_6 - 66.49678X_7$	98.2
Per capita use of all grains to make alcoholic beverages	
$X_8 = 105.16 + 0.35860X_9 - 0.71701X_{10} + 0.00501(X_{11})^2$	89.0
$X_8^* = 119.78 + 0.35215X_9 - 0.84894X_{10}$	87.6
$\text{Log } 10X_{12} = -1.1319 + 0.147526 \text{ Log}_{10}X_{11} + 0.939020X_{10} + 0.000204X_{13}$	88.9

Description of variables

X_1 = Per capita consumption of beef, pounds, carcass weight.

X_2 = Per capita disposable personal income, 1958 dollars.

X_3 = Retail price per pound of beef (estimated wtd. avg. price of retail cuts, cents), deflated by consumer price index for all food commodities

X_4 = Corn grindings by wet process, thousand bushels.

X_5 = FRB index for food manufacturers (1957-59 = 100)

X_6 = 0 any year before 1961; same value as X_5 any year after 1960.

X_7 = Corn oil, Decatur, crude, cents per pound, deflated by index of prices received by U.S. farmers for all oil-bearing crops (1957-59 = 100), times 100, lagged 1 year.

X_8 = All grains used to make fermented malt liquors, pounds per person 17-69 years of age, year beginning July 1.

X_9 = Personal consumption expenditures for alcoholic beverages in dollars per capita, deflated by consumer price index for all items, for previous calendar year.

X_{10} = Wholesale price index for alcoholic beverages deflated by consumer price index for all items, for previous calendar year.

continued--

Table 99. Relationships Between Selected Independent Variables and Domestic Consumption of Indicated Meats and Uses of Grains for Food and Alcoholic Beverages, 1948-65, Continued--

Per capita consumption of lamb and mutton and veal	Percent of variation explained
$X_{14} = 16.02 - 0.14002X_{11} + 0.00441^{\#}(X_{11})^2 - 0.0990X_{15} - 3.94599X_{16}$	85.7
$X_{17} = 38.62 - 8.50282(\text{Log}_{10}X_{18})^2 - 1.94903(\text{Log}_{10}X_{11})^2 - 8.74215^{\#}\text{Log}_{10}X_{19}$	98.9
Per capita consumption of wheat for food uses	
$X^{*}_{20} = 11.79 - 0.00843X_2 + 0.00000193889(X_2)^2$ D.W. statistic indicates that residuals are not serially correlated.	96.9
$X^{*}_{20} = 3.63 - 0.07618X_{11} + 0.00183(X_{11})^2 - 0.00101X_{21}$	99.3

Description of variables

X_{11} = Time, 1948 = 1

X_{12} = Taxable withdrawals of whiskey from warehouses, gallons per ten persons between 17-69 years of age.

X_{13} = First difference, X_2

X_{14} = Per capita consumption of lamb and mutton, pounds, carcass weight.

X_{15} = Retail price per pound of lamb, choice grade, in cents, deflated by consumer price index for all food commodities.

X_{16} = Ratio of lamb price (X_{15}) to beef price (X_3).

X_{17} = Per capita consumption of veal, pounds, carcass weight.

X_{18} = Retail price per pound, veal cuts, cents, deflated by consumer price index for all food commodities.

X_{19} = Ratio of veal price (X_{18}) to beef price (X_3).

X_{20} = Per capita consumption of wheat for food, bushels.

X_{21} = Average price received by farmers for wheat, cents per bushel, adjusted since 1964 for value of millers certificate, deflated by consumer price index for all food commodities, and multiplied by 100.

Statistical Reliability of Regression Coefficients

*Indicates that all regression coefficients in this equation are significantly different from zero, statistically speaking, at 95 percent level of probability.

#Indicates that this particular regression coefficient is not significant, in the above sense. (All other regression coefficients not so marked are significant).

Table 100. Selected Economic Determinants of U.S. Domestic Consumption of Cotton Fiber for All Purposes and for Apparel Manufacturing, 1965 and Estimated Values for 1980 and 2000

Predetermined factor (independent variable)	1965 (Actual)	1980			2000		
		Low	Medium	High	Low	Medium	High
End Use							
All and apparel; FRB index for apparel products; index no.	145.1	257.4	280.4	288.5	488.6	577.7	638.6
All uses; FRB index for textile mill products; index no.	134.9	207.9	223.8	229.3	365.7	426.6	468.2
All uses; FRB index for textile mill products, first difference of index no. ...	+12.0	+5.18	+6.18	+6.525	+15.0	+10.1	+11.9
All uses; cotton consumption/rayon and acetate consumption; first difference of three year average	+0.02	-.0627	-.0656	0.0	-.12	-.03	0.0
Apparel only; cotton goods/prices of man-made textile fibers; ratio of wholesale price indexes	1.04	1.11	1.08	1.06	1.3	1.15	1.08

Source: 1965 data from [16].

Table 101. Statistical Relationships Between Selected Independent Variables and Domestic Consumption of Cotton Lint, 1948-65

Per capita consumption of cotton for all purposes	Percent of variation explained
$1/X_1 = 0.07578 + 0.00078X_3 - 0.00111X_2 + 0.00012^{\#}X_4$ (D.W. statistic indicates that residuals are not serially correlated)	90.1
$1/X_1 = 0.07608 + 0.00080X_3 - 0.00113X_2 + 0.00014^{\#}X_4 - 0.00268^{\#}X_5$ (D.W. statistic indicates that residuals are not serially correlated)	91.8
Total consumption of cotton for apparel manufacturing	
$X_6 = -3774.0 + 3315.055755 \text{ Log}_{10}X_3 - 1152.258620X_7$	97.8

Description of variables

X_1 = Per capita domestic consumption, pounds

X_2 = FRB index of textile mill products (1957-59 = 100)

X_3 = FRB index of apparel products (1957-59 = 100)

X_4 = First difference of X_2

X_5 = Ratio of cotton consumption to rayon and acetate consumption, 3-year average centered on middle year, first difference

X_6 = Total domestic consumption of cotton for apparel, million pounds

X_7 = Ratio of indexes of wholesale prices of cotton goods to man made textile fiber products, lagged 1 year

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#These regression coefficients were not statistically different from zero at 95 percent level of probability. The rest of the coefficients in these two equations were significant, in this statistical sense.

APPENDIX TO CHAPTER IV

CHEMICALS AND FERTILIZERS

Analytical Procedures Used

The regression equations used to project the consumption by industry of phosphate rock, potash, and sulfur are described in table 102. Projections were based on the predetermined values of industrial output identified in table 103. The methods for calculating these values for each independent variable (except FRB index of total industrial production) are summarized in table 104 footnotes. All of these projections are consistent with the assumptions concerning projected industrial output (total or nondurable manufactures) presented in Chapter II of this report.

Alternate regression equations were developed to explain industrial use of phosphate rock and sulfur. None was used for projecting future consumption. Phosphate rock consumption for industrial purposes between 1948 and 1965 was explained in a less satisfactory manner as a function of the common logarithms of a composite use index ($R^2 = 0.945$). This index consisted of the sums of the FRB index of industrial production of soap and related products times 0.333 plus the FRB index for chemical, petroleum and rubber multiplied by 0.667. The quantity of phosphate rock reduced to phosphoric acid during 1948-65 also was explained as a function of common logarithms of the FRB index of industrial chemical production. Less annual variation was explained by this transformation of the independent variable ($R^2= 0.964$), and the relationship seemed less appropriate for forecasting purposes than did the linear function selected.

Apparent domestic sulfur consumption between 1948-65 was explained more by total industrial production than by a special composite use index. The simple regression equation using this special index explained 97.5 percent in annual variation in consumption. The index was calculated as the sum of the FRB index for fertilizer manufactures times 0.333 and the FRB index for chemicals, petroleum, and rubber multiplied by 0.667. Evidently the industrial uses of sulfur were so diverse that no simple improvements could be made on total industrial output as an explanatory factor.

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Analytical Procedures Used to Project Consumption of Phosphate Rock and Potash for Fertilizer

The multiple regression equations selected to project agricultural demand for phosphate rock and potash are described in tables 105, 106 , and 107. The second equation for phosphate rock was used only to predict high consumption in 1980 under the stipulation that major advances in phosphatic fertilizer technologies would occur during the next decade.

The projections were made with the aid of these estimating equations, using the predetermined (calculated) values of independent variables shown in table 103. Methods used to select these assumed values are outlined in table 104.

The equations actually used for projecting consumption represent the "best" solutions from about 60 different models or specific combinations of variables. For phosphate rock, different combinations of 11 independent variables and the consumption variable were tested, and mathematical transformations of this basic data enabled the step-wise multiple regression program to select from a total of 38 variables. The analysis of potash consumption was equally extensive. Here, 8 independent variables and the dependent variable were transformed, usually by logarithms, reciprocals, and raising the variable to the second power, into 35 "different" variables.

Final selection of equations was based on the economic logic and statistical significance attributable to the net regression coefficients, as well as to the percentage of variation explained in the past (1948-65), or "closeness of fit." The presence of serial correlation among the residuals, as detected by the Durbin-Watson Statistic, was sufficient to eliminate that equation from use for projecting consumption.

Projections of Exports of Phosphate Rock, Potash and Sulfur

Preliminary calculations of projected exports of these three minerals were based on linear or logarithmic projections of trends in exports between 1954-66 for phosphate rock and potash, and 1962-66 for sulfur. Adjustments to these calculated values were made in most cases. Generally, these modifications reflected shares of world trade in fertilizer materials acquired recently by U.S. exporters, explicit

growth rates in fertilizer consumption and production in developing nations, and similar projections for Western Europe and Japan. Potash shipments reflected estimates of the quantities of Canadian production estimated to be available for importation into the United States. Sulfur projections were consistent with export shipments projected for phosphate rock, since demand for both minerals will be closely related to the needs of foreign fertilizer manufacturers.

For example, high projections for phosphate rock were consistent with estimated growth of world consumption of phosphate fertilizers through 1975. Subsequently, we assumed that important new phosphate mines would reduce the U.S. share of this trade by as much as 40 percent. On the other hand, our lowest projection is that as much as 15 percent of our established markets will be lost to other exporters by 1980. Between 1980 and 2000, more phosphates should be exported since processed phosphates and important new phosphate rock deposits recently discovered in several continents should supply more of the phosphate needs for India-Pakistan and other less-developed regions.

In contrast, low projections for potash exports were based on extrapolations consistent with the assumption that most potash will be supplied by Canada and Europe. Therefore, U.S. exports would expand at a decreasing annual rate, roughly proportionate to the logarithmic function of time (1954 = 1). Our highest projections of potash shipments during the next 15 years reflect extrapolation of linear trends since 1954. After 1980, highest estimates imply that potash shipments will grow increasingly rapidly, reaching annual growth rates in the 1990's comparable with the estimated growth rate of world fertilizer used then (10 percent each year). These enormous estimates are also consistent with these implied assumptions: (1) That U.S. exporters by 1990 will regain recent cent shares of foreign markets in developed and emerging nations; (2) that slightly more potash relative to phosphate will be used in less developed countries than under current fertilizer practices (i.e., that the nutrient ratio of $N:P_2O_5:K_2O$ will be 4:2:1.5).

Parameters for sulfur exports were established in a similar manner. However, none of the projections implied that sulfur exports would grow at an increasing (exponential) rate, compared with 1962-66 trends. Highest projections for sulfur shipments were constrained by estimates of phosphate rock available for export. Our lowest projections implied that sulfur exports would expand, on the average, at annual increments which would decrease over time. Medium projections through 2000 imply that exports will, on the average, increase approximately 23 percent each decade during the next 40 years.

Development of Historic Time Series of Domestic Consumption by Principal End Uses and Gross Exports

Annual data reflecting consumption of phosphorous pentoxide, potassium oxide, and sulfur from 1948 through 1965 are included in tables 108, 109, and 110. Neither the Bureau of Mines nor the U.S. Department of Agriculture statistical reports contained annual estimates of gross quantities of the two chemicals used in fertilizer manufacturing [7, 9]. Briefly, USDA consumption series underestimate shipments to agricultural customers, especially in the case of phosphate rock. On the other hand, Bureau of Mines data of consumption for domestic agricultural purposes were much higher than warrented by the reported output of agricultural chemicals, including fertilizers, particularly since 1960. In the case of potash, equivalent series diverged sharply during the 1960's. The two series presented here attempt to reconcile these differences.

Domestic consumption of these raw materials includes all or most of the quantities processed by domestic manufacturers for both domestic and export sales. Although some double counting may be included in these series, it is probably more than offset by incomplete reporting of foreign trade with Canada and Mexico. Further complicating practica consideration of developing precise measurements of historical consumption of these minerals are the following factors: low values per ton, huge quantities shipped or used, and inadequate sampling of the quantities of chemical compounds or sulfur contained in shipments of raw materials.

Table 102. Relationship of Annual Domestic Consumption of Phosphate Rock and Potash by Nonagricultural Industries, Sulfur for All Purposes, and Use of Phosphate Rock and Sulfur to Produce Phosphoric Acid and Sulfuric Acid for Domestic Consumption and Export, with Selected Measures of Industrial Output, 1948-65[a]

Annual consumption	FRB index used as consumption determinant[b]	Factor by which FRB index is multiplied[c]	Constant (a) added	Percent explained of variation in consumption[d]
Phosphate rock for industrial purposes	Industrial chemicals[e]	1,512.625911	-2,083.61	95.1
Phosphate rock reduced to phosphoric acid (including acid produced for export)	Industrial chemcials	20.81455	-423.46	98.9
Potash for industrial purposes[f]	Composite use index	2.195965	-90.65	98.6
Sulfur for all uses	Total industrial production	44.612373	1,194.05	95.7
Sulfuric acid[g]	Total industrial production	173.30626	-626.83	98.1

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a/ Phosphate rock consumption in thousand long tons, P_2O_5 content; potash in K_2O equivalent; sulfur for all uses in thousand tons; sulfuric acid, see footnote g/.
b/ For futher description of independent variables, see table 104, footnotes.
c/ Coefficients of regression.
d/ Coefficients of determination (R^2) multiplied by 100.
e/ Independent variable is in common logarithms.
f/ 1948 omitted from data from which regression equation was calculated.
g/ Expressed in thousand short tons, 100 percent H_2SO_4. To convert to sulfur, multiply by factor 0.26948.

Source: [1].

Table 103. Selected Economic Determinants for Domestic Use of Phosphate Rock and Potash, 1965 and Calculated 1980 and 2000

End use and commodity	Predetermined factor (independent variables)	1965 (Actual)	1980			2000		
			Low	Medium	High	Low	Medium	High
Agricultural use of:								
P_2O_5 and K_2O	Deposits of country banks (index no.)	176	312.5	341.5	351.7	146.1	766.2	848.2
P_2O_5	Fertilizer price/farm production costs; ratio of index numbers	55.9	56.1	53.3	51.4	56.1	49.1	48.1
P_2O_5	Nutrient price ratio: P_2O_5/K_2O; first difference of ratio of deflated prices	+0.100	+0.195	+0.079	-0.037	+0.195	+0.079	-0.037
P_2O_5	Total cash receipts from crops and livestock; first difference of index numbers	-1.3	-4.3596	-0.11667	+4.12628	-4.3596	-0.11667	+4.12628
K_2O	Potash price factor	.388	.353	.382	.411	.255	.382	.435
Industrial use of:								
P_2O_5	FRB index of industrial chemical production	196.3	452.8	504.9	523.1	971.4	1171.8	1308.7
K_2O	Composite use index	136.4	238.4	259.0	266.1	442.5	521.3	575.1

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[a] For detailed description of these series, including methods of estimating (predetermining) values in 1980 and 2000, see corresponding rows and footnotes of table 104.

Table 104. Selected Economic Determinants for Domestic Consumption of Phosphate Rock and Potash: Changing Patterns Between 1948 and 1965, and Methods of Projections to 1980 and 2000[a]

Explanatory Factor	Past trends in three-year averages		
	1948-50	1955-57	1963-65
Deposits of country banks (index numbers)[b]	100.0	122.0	165.0
Fertilizer prices/farm production costs[c]	60.4	61.5	56.1
Nutrient price ratio: P_2O_5/K_2O; first difference[d]	+0.107	+0.095	+0.064
Total cash receipts from crop and livestock sales; index numbers of (first differences)[e]	-4.5	-2.0	+2.2
Potash price factor[f]	0.468	0.422	0.382
FRB index of industrial chemical production[g]	42.6	89.8	179.1
Composite use index (potash)[h]	77.5 (1949-51)	96.4	129.0

Continued--

Table 104. Continued--

a/ Methods of calculating assumed (predetermined) values are summarized below (b/ through h/):

Regression equation $Y = 0.29772X - 8.73$, where
X = GNP, in billions of 1958 dollars.
This relationship was developed from 1948-65.

b/ Index number of total deposits of country banks in 20 of the leading agricultural States (1947-49 = 100), for previous year.

c/ For low assumptions, 1963-65 averages were used.
For medium assumptions, regression equation $\log Y = 1.7853 - 0.001782X$, where X = time (1980 = 33, 2000 = 53).
For high assumption, regression equation $Y = 76.23 - 16.320911 \log X$, where X is time as above.
First equation was developed from 1948-65, and second 1956 (X = 8) through 1965.
Ratio of index numbers of prices paid by farmers for fertilizer to all the commodities bought for use in production, multiplied by 100, for previous year (in both series of index numbers, 1910-14 = 100).

d/ For low assumptions, 1948-65 average (+0.079) plus one standard deviation of this factor for same 18-year period (+0.116).
For medium assumptions, 1948-65 average.
For high assumptions, 1948-65 average minus one standard deviation.
Average annual price of P_2O_5 divided by equivalent price of K_2O. Both prices deflated by wholesale price index for all items. Transformation before use in regression estimating equations: first difference of values (current year less previous year). P_2O_5 and K_2O price series are based on quotations of raw materials at mines (Florida and Carlsbad, New Mexico, respectively).

e/ For low assumptions, 1948-65 average (-0.11667) minus one standard deviation of this factor for same 18-year period (+0.424295).
For medium assumptions, 1948-65 average.
For high assumptions, 1948-65 average plus one standard deviation.
Index of total cash receipts from crop and livestock sales (1957-59 = 100), deflated by wholesale price index for all items and multiplied by 100. First difference transformation: current year minus last year.

Continued --

Table 104. Continued--

f/ For low assumptions: 1980, 1957-65 average; 200, $\log Y = 1.671527 + 1.991979X$, where X is a function to time (200 = 33).
For medium assumptions, 1963-65 average.
For high assumptions, 1948-65 average, adjusted upward slightly for 2000.
K_2O raw material price deflated by wholesale price index for all items, for previous year.

g/ Regression equation $Y = 2.218487X - 120.27$, where X = FRB index for total nondurable manufactures. This relationship was developed from 1948-65.
FRB index of industrial chemical production (for same year) (1957-59 = 100), not seasonally adjusted.

h/ Regression equation $Y = 13.03 + 0.872727X$, where X = FRB index for total nondurable manufactures. This relationship was developed from 1948-65.
Composite use index = sum of FRB index for clay, glass, and lumber times 0.333 plus FRB index for total nondurable manufactures times 0.667, for same year.

Sources: Index numbers of total deposits of country banks, prices paid by farmers, developed by U.S. Department of Agriculture, Economic Research Service [8].

Index of total cash receipts from crops and livestock sales (1957-59 = 100) from U.S. Department of Commerce [10, 11].

Series based on farm income statistics [8].

P_2O_5 and K_2O prices developed from data published annually.

Wholesale price index by the U.S. Department of Commerce [11].

FRB Indexes were 1957-59 = 100 not seasonally adjusted annual indexes [1, 2].

Table 105. Standard Error of Estimate, the Coefficient of Multiple Determination (R^2), Constant (a), Multiple Regression Coefficients, and Related Matters Pertaining to the Indicated Independent Variables and their Relation to Annual U.S. Consumption of Phosphate Rock as Fertilizer, 1948-65[a]

Variable (and mathematical transformation)	Net regression coefficient	Statistical reliability of net regression coefficients[b]	Relative importance of independent variable in explaining variation in annual consumption[c]
	(Standard error of estimate = , R^2 - 0.952, Constant (a) = 3289.15)		
Deposits of country banks (index No.) (natural logarithm of)	2,085.207	12.109	0.83138
Fertilizer price/farm production costs (natural logarithm of)	-2,612.586	- 3.346	(-)0.2297
Nutrient price ratio: P_2O_5/K_2O; first differences	-. 465.84976	- 2.067	(-)0.12166

Durban Watson statistic: 1.01654. Test for serial correlation among residuals inconclusive.

a/ Consumption of phosphate rock in thousand long tons, P_2O_5 content; independent variables are described in table 104, footnotes.
b/ Ratio of net regression coefficient to its own standard error. Except when otherwise noted, this test (test of student's "t" ratio or statistic) indicated that these regression coefficients are statistically different from zero, at probabilities greater than 95 percent.
c/ Relative importance was determined by the comparative sizes of the beta coefficients of those variables. These beta coefficients (net regression coefficients divided by their own respective standard deviations and then multiplied by the standard deviation of the dependent variables) rank independent variables roughly in ascending order of importance. (The mathematical sign should be disregarded.)

Table 106. Standard Error of Estimate, the Coefficient of Multiple Determination (R^2), Constant (a), Multiple Regression Coefficients, and Related Matters Pertaining to the Indicated Independent Variables and their Relation to Annual U.S. Consumption of Phosphate Rock as Fertilizer, 1948-65[a]

Variable (and mathematical transformation)	Net regression coefficient	Statistical reliability of net regression coefficients[b]	Relative importance of independent variables in explaining variation in annual consumption[c]
	(Standard error of estimate = 0.0196,* R^2 = 0.93,[b] Constant (a) - 3.35432*[c])		
Time (trend), 1948 = 1; 1965 = 18 (squared)	0.00058	11.6	0.84413
Total cash receipts from crop and livestock sales; index numbers (first differences)	0.00268	2.144	0.23405

Durban Watson statistic: 0.86. Test for serial correlation among residuals inconclusive.

* Dependent variable is expressed in natural logarithms.
a/ The independent variables are different from those used in the equation shown in table 105. Consumption of phospate rock is expressed in common logarithms of actual consumption, in thousands of long tons, P_2O_5 content; for description of second independent variable, see table 104 and footnotes.
b,c/ See table 105, corresponding footnotes.

Table 107. Standard Error of Estimate, the Coefficient of Multiple Determination (R^2), Constant (a), Multiple Regression Coefficients, and Related Matters Pertaining to the Indicated Independent Variables and their Relation to Annual U.S. Consumption of Potassium Fertilizer Materials,a/ 1948-65

Variable (and mathematical transformation)	Net regression coefficient	Statistical reliability of net regression coefficientsb/	Relative importance of independent variables in explaining variation in annual consumptionc/
	(Standard error of estimate = 112.88, R^2 = 0.970b/, Constant (a) = 10,311.00c/)		
Deposits of country banks (index No.) (reciprocal of)	-480,703.72266	14.9	- 1.43803
Potash price factor	-4,948.75513	1.23*	- 0.57151
Potash price factor (reciprocal of)	- 919.26120	1.51*	- 0.68369

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* These coefficients were not statistically different from zero at 95 percent probability. These variables were retained, however, because the significance of their coefficients was verified in several other versions of the same basic equation (i.e., different cases of the same step-wise multiple regression program).

a/ Consumption of potash is expressed in thousand short tons, K_2O equivalent. For description of independent variables, see table 104 and footnotes.

b,c/ See table 105, corresponding footnotes.

Table 108. Phosphate Rock: Estimates of U.S. Exports and Domestic Consumption by Principal End Uses, Annually, 1948-65

(thousand long tons, P_2O_5 content)

Year a/	Exports, gross		Domestic consumption			Reduced to phosphoric acid for consumption in U.S. or exported
			Agricultural use			
	Total Bureau of Mines	Additional, reported by Census	Calculated use by fertilizer manufacturers	Bureau of Mines	Industrial use	
	(1)	(2)	(3)	(4)	(5)	(6)
1948.......	337	n/c	2,066	2,108	295	385.7
1949.......	437	23.0	2,145	2,069	335	450.9
1950.......	568	n/c	2,154	2,268	417	530.3
1951.......	535	n/c	2,394	2,321	625	597.3
1952.......	437	n/c	2,516	2,550	565	666.9
1953.......	636	n/c	2,502	2,385	843	856.2
1954.......	752	n/c	2,484	2,437	792	1,016.1
1955.......	717	27.2	2,449	2,666	793	1,174.1
1956.......	876	62.4	2,501	2,688	868	1,233.9
1957.......	977	37.1	2,533	2,664	923	1,400.9
1958.......	887	n/c	2,525	2,784	944	1,525.9
1959.......	956	n/c	2,801	3,141	917	1,679.4
1960.......	1,290	81.9	2,756	3,090	972	1,863.4
1961.......	1,261	65.3	2,865	3,243	1,047	2,012.5
1962.......	1,269	98.6	2,978	3,457	1,201	2,184.8
1963.......	1,480	194.6	3,263	3,553	1,154	2,593.7
1964.......	1,835	(12.5)	3,531	3,648	1,424	2,931.2
1965.......	2,065	(0.3)	3,642	4,512	1,471	3,433.0

Table 108. Continued--

a/ Calendar years, except for Column (3) figures which are for years ending June 30.

Sources:

(1) Exports of phosphate rock as reported to Bureau of Mines by domestic producers. P_2O_5 content derived by Bureau of Mines [7]. Does not include all exports of processed phosphates in phosphatic and mixed fertilizers.

(2) For selected years, difference between Bureau of the Census and Bureau of Mines exports [3, 7]. Actual weight of phosphate rock converted into P_2O_5 content by Robert R. Nathan Associates, Inc., n/c = not calculated.

(3) Calculated use to make fertilizers. Based on USDA [9] reports of available P_2O_5 consumed in all commercial fertilizers, adjusted by Robert R. Nathan Associates to include P_2O_5 content of direct-applied raw rock phosphate and then to include a 12-percent allowance for transportation, mixing, and storage losses, and exports of mixed fertilizers.

(4) Phosphate rock sold or used by producers in the United States for domestic agricultural purposes as reported to the Bureau of Mines by domestic producers. P_2O_5 content derived by Bureau of Mines [7]. Since 1955, includes rock for phosphoric acid reduced by "wet" process. Includes requirement for livestock and poultry feed equal to about 2 percent of reported agricultural use. Not adjusted for inventories or for phosphates which are processed into phosphatic fertilizer materials or mixed fertilizers before being exported.

(5) Phosphate rock sold or used by producers in the U.S. for domestic industrial purposes, as reported to Bureau of Mines. P_2O_5 content derived by Bureau of Mines [7]. Prior to 1955 Bureau of Mines figures were adjusted by Robert R. Nathan Associates to remove phosphate rock used to make "wet" process phosphoric acid.

(6) Based on Bureau of the Census [3] reports on phosphoric acid production, 1,000 short tons of 100-percent P_2O_5.

Table 109. Potash: U.S. Exports and Estimates of Domestic Consumption by Principal End Uses and Apparent Total, 1948-65

(thousand short tons, approximate K_2O equivalent)

Year[a]	Exports gross	Domestic consumption: Calculated use by fertilizer manufacturers	Domestic consumption: Reported consumption in fertilizers, USDA	Domestic consumption: Consumption by chemical industries	Domestic consumption: Total apparent domestic consumption Bureau of Mines	Possible error in end use estimates (6)=(2)+(4)-(5)
	(1)	(2)	(3)	(4)	(5)	(6)
1948...	70	967.05	921	2	--	--
1949...	70	1,126.65	1,073	68	1,070.3	124
1950...	65	1,158.15	1,103	87	1,411.6	(166)
1951...	69	1,449.00	1,380	89	1,653.4	115
1952...	56	1,661.10	1,582	88	1,730.5	19
1953...	49	1,824.90	1,738	105	1,817.0	1.2
1954...	66	1,904.70	1,814	93	1,971.0	26.7
1955...	130	1,968.75	1,875	116	2,054.0	30.7
1956...	226	2,062.50	1,875	126	2,058.0	130.5
1957...	234	2,130.70	1,937	128	2,085.0	173.7
1958...	254	2,128.50	1,935	114	2,281.0	(39.0)
1959...	337	2,410.10	2,191	139	2,373.0	176.0
1960...	491	2,368.30	2,153	140	2,337.0	171.0
1961...	473	2,494.35	2,169	149	2,276.0	367.0
1962...	506	2,611.65	2,271	164	2,557.0	218.6
1963...	425	2,878.45	2,503	173	2,878.0	173.4
1964...	618	3,108.45	2,703	193	3,164.0	137.4
1965...	648	3,260.25	2,835	219	3,391.0	88.2

Table 109. Continued--

a/ Calendar years, except Columns (2) and (3) which are for years ending June 30.

Sources:

(1) Exports of potash materials (fertilizer and chemical) by U.S. Bureau of Census [3], adjusted to approximate K_2O equivalent by Bureau of Mines. In terms of tonnage, chemical exports recently represented between 1.7 and 4.2 percent of total. Does not include potassium content in mixed fertilizers.

(2) Based on reported consumption in all commercial fertilizers, (column (3)) adjusted by an allowance for transportation, mixing, and storage losses by Robert R. Nathan Associates. This factor varied from 5 percent, increased to 15 percent by 1961. Presumably includes ample allowance for potassium materials included in mixed fertilizers subsequently exported which are not included in column (1).

(3) Compilations by Statistical Reporting Service [9], based upon reports of fertilizer inspection services of the various States. Includes no allowance for nutrient loss prior to delivery to farmer customers, and only estimates output of noninspected manufacturers.

(4) Deliveries of chemical potash by domestic producers, as reported by The American Potash Institute, plus imports for consumption chiefly in chemcial industries, as collected by U.S. Bureau of Census [3]. Includes potassium components subsequently exported, chiefly as chemical exports, and included in column (1). Approximate K_2O equivalent estimated by Bureau of Mines [7].

(5) Calculated by Bureau of Mines, representing potash sold or used, plus imports minus exports [7].

Table 110. Sulfur in All Forms: U.S. Total Disappearance, Exports, Apparent Total Domestic Consumption, and Estimated Consumption to Produce Sulfuric 1948-65

(Thousand long tons, sulfur content)

Year	Total disappearance domestic & export	Exports	Apparent total domestic consumption		
			All forms	Native sulfur	Sulfur used in production of sulfuric acid
	(1)	(2)	(3)	(4)	(5)
1948	5,722	1,295	4,427	3,720	3,087
1949	5,554	1,461	4,093	3,409	3,080
1950	6,466	1,478	4,988	4,158	3,511
1951	6,130	1,311	4,819	3,786	3,603
1952	6,171	1,338	4,833	3,728	3,586
1953	6,317	1,271	5,046	3,930	3,773
1954	6,586	1,675	4,911	3,698	3,874
1955	7,261	1,635	5,626	4,245	4,380
1956	7,418	1,675	5,743	4,267	4,445
1957	7,145	1,592	5,553	3,997	4,435
1958	6,862	1,598	5,264	3,655	4,298
1959	7,552	1,635	5,917	4,232	4,745
1960	7,647	1,786	5,861	3,950	4,819
1961	7,489	1,596	5,893	3,908	4,809
1962	7,797	1,554	6,243	4,064	5,309
1963	8,219	1,613	6,606	4,300	5,641
1964	9,189	1,928	7,261	4,738	6,177
1965	10,644	2,651	7,993	5,097	6,696

Continued--

Table 110. Continued--

Sources:

(1) Column (2) plus (3).

(2) U.S. Bureau of the Census, Published by Bureau of Mines [7].

(3) Native sulfur sales (domestic plus imports) adjusted for net change in producer's stocks, recovered sulfur and pyrites (sales or production plus imports), plus all other forms produced domestically. Bureau of Mines calculations [7].

(4) Apparent sales of native sulfur to consumers, adjusted for changes in inventory, plus imports of native sulfur, minus exports in column (2). All sulfur exports were assumed to be from native sulfur, crude and refined. Calculated by Robert R. Nathan Associates.

(5) Based partly in Bureau of the Census data on all sulfuric acid, in terms of tons of 100-percent H_2SO_4 [3]. This production series was converted to approximate sulfur consumption by multiplying by 0.26948. Calculations by Robert R. Nathan Associates.

APPENDIX TO CHAPTER V

SELECTED METALS AND OTHER NONFUEL MINERALS

The tables in this Appendix provide the estimating equations that were used in making projections of metals and mineral consumption in 1980 and 2000. The independent variables, estimating equations, and coefficients of correlation are listed in table 111. Historical data on consumption from 1948-65 are shown in table 112, and exports in table 113. Most of the historical data came from the *Minerals Yearbook*, Bureau of Mines [7]. All of the data are consistent with Bureau of Mines figures, but other sources have been used, as indicated, where the organization was more useful for our purpose.

The only regional projections made were those for sand, gravel, and aggregates. For this category, table 114 sets forth the derivation of regional demand for aggregates by percentage distribution of the value of construction by region.

The indexes that were used as independent variables were projected in Chapter II of this report, with the exception of the Federal Reserve Board index of construction materials. The construction index was projected by correlation with gross national product, as shown in table 115.

Table 112. U.S. Demand for Selected Metal and Mineral Commodities, 1948-65, Continued--

Year	Mercury[d]	Manganese[d]	Nickel[d]	Molybdenum[c,g]	Molybdenum[b,g]	Tungsten in steel[h]	Tungsten[i]	Vanadium[d]	Diatomite[j]	Sand, gravel & crushed stone[d]
	Thou. flasks	Thousand short tons		------------Million pounds------------				Short tons	Thousand short tons	Million short tons
1948...	46.3	1,538.4	93.6	20.2		5.7	3.2	710	240.9	543.2
1949...	39.9	1,265.2	68.3	20.0	25.3	3.2	1.8	540	240.9	541.5
1950...	49.2	1,520.5	100.0	26.0	32.3	3.0	3.8	913	240.9	620.1
1951...	56.8	1,710.8	86.7	33.7	37.4	3.4	8.0	1,616	302.8	684.3
1952...	42.6	1,714.0	101.4	32.7	38.9	2.1	6.5	1,525	302.8	735.3
1953...	52.3	2,057.9	105.7	31.2	38.2	2.8	4.9	1,613	302.8	745.3
1954...	42.8	1,637.8	94.7	24.7	38.3	1.3	2.8	1,702	368.4	966.2
1955...	57.2	2,017.6	110.1	38.8	43.4	2.9	6.0	1,880	368.4	1,060.2
1956...	54.1	2,264.2	127.6	42.7	60.6	3.9	5.9	2,200	368.4	1,128.5
1957...	52.9	2,273.8	122.5	39.0	64.4	2.8	5.3	2,000	449.8	1,161.8
1958...	52.6	1,414.6	79.0	31.3	43.3	1.7	3.8	1,400	449.8	1,217.9
1959...	54.9	1,515.9	112.7	37.4	56.3	3.1	6.6	2,101	449.8	1,311.9
1960...	51.2	1,946.4	108.2	44.8	75.0	2.3	6.8	2,240	482.2	1,324.3
1961...	55.8	1,717.8	118.5	42.3	77.9	2.3	6.8	2,240	482.2	1,364.9
1962...	65.3	1,865.3	118.7	41.0	56.5	2.7	9.1	2,571	482.2	1,430.9
1963...	78.0	1,841.7	124.5	49.2	75.7	2.9	7.7	2,906	580.3	1,508.7
1964...	82.6	2,241.8	146.9	56.4	81.3	2.7	8.4	3,550	580.3	1,591.8
1965...	76.5	2,866.1	172.1	48.6	72.7	3.2	10.4	4,708	580.3	1,685.7

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[a] Domestic shipments plus exports plus imports [1].
[b] Domestic consumption including imports plus exports.
[c] Domestic consumption including imports.
[d] Bureau of Mines [7].
[e] Copper Development Association [2].
[f] Bureau of Mines [7]. A longer series (1941-66) was used for the projection (see Appendix)
[g] Bureau of Mines and Bureau of Census [6, 7].
[h] Included with molybdenum [7].
[i] Excluding tungsten used in steel making [7].
[j] Figures are three-year average sales reports, includes exports [7].

Source: [1, 2, 6, 7].

Table 113. Export Demand for Selected U.S. Metals and Minerals, 1948-65

	Iron Ore[a]	Aluminum	Magnesium	Molybdenum	Diatomite
	Mil. long tons	------Thousand short tons----		Mil. lbs.	Thou. short tons
8 .	2.7	49.5	.4		n.a.
.	2.4	37.2	.7	5.3	n.a.
0 .	2.5	21.3	.9	6.2	n.a.
.	4.3	13.4	.8	3.7	n.a.
.	5.1	10.3	1.2	6.2	n.a.
3 .	4.4	14.7	3.0	7.0	n.a.
.	3.1	49.4	3.3	13.5	n.a.
5 .	4.5	32.3	8.5	14.6	n.a.
.	5.5	66.4	3.9	18.0	n.a.
7 .	5.0	59.9	1.6	25.5	n.a.
.	3.6	80.8	1.1	12.0	60
9 .	3.0	162.5	2.4	18.9	71
.	5.3	382.6	5.1	30.2	92
1 .	5.0	236.1	6.7	35.7	95
2 .	5.9	258.7	7.0	15.6	109
.	6.8	291.7	16.2	26.5	112
4 .	7.0	349.4	16.8	24.9	128
.	7.1	313.8	17.8	24.1	114

G oss weight.

: [1, 6, 7].

Table 114. Value of Construction in the United States, by Region, 1965 and Projected 1980 and 2000

(Values in 1958 dollars)

Region	1965		1980		2000
	Mil. dol.	Percent	Mil. dol.	Percent	Percent
United States..	25,163		61,876		
Northeast.....	6,313	25.1	14,397	23.3	21.5
North Central.	6,079	24.2	15,747	25.5	26.7
South.........	6,877	27.0	16,540	26.7	26.5
West:					
Montana......	153	0.6	349	0.6	0.6
Idaho	166	0.7	296	0.5	0.4
Wyoming......	25	0.1	188	0.3	0.3
Colorado	373	1.5	1,245	2.0	2.4
New Mexico ..	111	0.5	377	0.6	0.7
Arizona	356	1.4	1,251	2.0	2.5
Utah.........	230	0.9	575	0.8	0.7
Nevada	227	0.9	314	0.5	0.4
Washington ..	439	1.8	1,001	1.6	1.4
Oregon	265	1.1	670	1.1	1.1
California ..	3,439	13.7	8,329	13.5	13.3

Source: 1965 data from [5].

Table 115. Federal Reserve Board Index of Construction Materials Compared with U.S. Gross National Product, 1948-65[a]

Year	FRB Index Construction materials[b]	Gross National Product[c]
1948...................	74.9	323.7
1949...................	68.5	324.1
1950...................	82.4	355.3
1951...................	86.8	383.4
1952...................	85.6	395.1
1953...................	91.0	412.8
1954...................	87.4	407.0
1955...................	97.3	438.0
1956...................	99.6	446.1
1957...................	99.4	452.5
1958...................	94.5	447.3
1959...................	106.0	475.9
1960...................	106.3	487.8
1961...................	105.2	497.3
1962...................	110.4	530.0
1963...................	116.3	550.0
1964...................	124.5	577.6
1965...................	133.8	616.7

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[a] $y = 7.063 + .2026\ x$ ($r = .9885$).
[b] 1957-59 = 100.
[c] 1958 prices.

Source: [4].

APPENDIX TO CHAPTER VI

MINERAL FUELS AND ELECTRICITY

The methods used in the projections of mineral fuels consumption and electric power requirements in the United States in 1980 and 2000 was essentially that used by Resources for the Future, Inc. (RFF), in a 1963 study [16]. The 1963 study and an earlier RFF study [18] are among the most detailed and comprehensive analyses of energy consumption in the United States published to date.

In projecting energy requirements in this study, the relevant historical series provided by RFF were updated and the RFF assumptions and projections were reexamined in the light of recent trends and developments. In addition, the RFF projections and estimates were revised, where appropriate, to include the projections of national economic aggregates developed in this study (i.e., population, GNP, employment, income, etc.).

Household Consumption

Household consumption of energy is the aggregate of the requirements for energy for each type of household use. Although the approach to projecting household energy requirements was essentially the same as the RFF approach, the values of most of the RFF variables were changed. Projections of electricity consumption in 1980 and 2000 presented here are generally about 15 percent higher than the medium projections made by RFF. The medium projection for gas, however, is only 2 percent higher than the RFF projections for 1980, and 9 percent higher than their projections for 2000. The estimates for electricity fall about 11 percent below those of Electrical World [8] for 1980 and about 7 percent below those of the National Power Survey [12]. However, the latter assumed a higher population and a larger percentage of electrically heated homes than are assumed here.

Five variables were used to obtain estimates of household consumption: (1) The number of households; (2) saturation factors for each major appliance (i.e., the number of households with spaceheat, television, ranges, etc.); (3) the percentages of each class of appliances using electricity,

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gas, coal, and oil; (4) annual energy requirements of each appliance by energy source (i.e., gas used by a gas range, electricity by an electric dryer, etc.); and (5) efficiency of conversion of spaceheating appliances, by energy source. The derivation of these variables is discussed below.

Number of Households

The number of households in 1980 and 2000 was obtained by using the ratios of households to population over 20 years of age implicit in the Census population and household projection series for 1980 [22, 23]. The low and high household projection ratios from the Census series were applied to the low and high population projections used in this study. The median of the low and high Census ratio was applied to the medium population projection in this study for 1980 and 2000. The number of households was the only variable affecting the range of estimates of household consumption and only one estimate was made for each of the other four variables.

Saturation Factor

The number of households having each of the appliances considered was derived from estimates of the saturation factor (i.e., percentage of households with the appliance).[1] The RFF data were updated to 1965, and the trends were extrapolated to 1980 and 2000. The RFF projections were generally used as guidelines. The saturation factors for the various appliances are discussed below:

Spaceheat. A factor of 100 percent was used in 1980 and 2000. It was assumed that all households will have some form of heating equipment.

Air conditioning. This sector is growing rapidly, and the saturation levels projected for 1970 by RFF were almost reached by 1965. Higher saturation factors were therefore projected for 1980 and 2000.

Television and refrigerators. The saturation factor of both appliances was nearly 100 percent in 1965; it is expected to be 100 percent by 1980 and to remain at this level through 2000.

Ranges. The saturation factor for ranges was already 105 percent by 1965 and a further increase was projected for 2000.

Water heaters. The saturation factor for water heaters was estimated to reach 100 percent by 2000. The estimate for 1980 was slightly higher than RFF's because of the more rapid rate of growth between 1960 and 1965 than was indicated in the RFF projections.

Freezers and dryers. The saturation factors for both freezers and dryers have increased at slower rates than expected by RFF, and saturation factors more in line with recent trends were used.

Electric lighting and miscellaneous electric appliances. A saturation factor of 100 percent was assumed for both these; i.e., all houses were assumed to be electrically lighted and to have some miscellaneous appliances.

Number of Appliances by Energy Source

The number of appliances using electricity, gas, oil, or coal was estimated on the basis of percentage of appliances using each energy source and the amount of energy required per appliance. The only household use of coal was spaceheating, and oil had only minor nonspaceheating uses.

The RFF data were updated to 1965 and the trends in percentage shares of different energy sources were extrapolated graphically to 1980 and 2000. The RFF estimates were used as guidelines.

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[1] Saturation factors are related to the number of households and not to the number of dwelling units. Historically, the number of dwelling units has been about 10 percent higher than the number of households. For this reason, saturation factors can exceed 100 since there may be more of some appliances than there are households.

A significant development in spaceheating in recent years has been the increased use of electricity. From 1960 to 1965 the number of homes with electric heat almost trebled. It was assumed that 18 percent of all households would use electric heat by 1980 and 40 percent by 2000. The medium projection of 13.7 million homes with electric heat in 1980 is somewhat lower than the National Power Survey [12] estimate of 19 million, but is considerably higher than RFF's projection of 9.1 million homes. The projections in this study imply that three-fourths of the incremental market will go to electricity by 1980, and all of it by 2000, plus a net gain as the result of the conversion from fuel-burning equipment to electricity. The number of households using fuels for spaceheating is, therefore, expected to decline by 2000.

Gas will probably continue to increase its share of the fuel requirements for spaceheat at the expense of coal, oil, and liquid petroleum gas (LPG). Oil's share was estimated to have decreased by 2.5 percent between 1960 and 1965 and this trend is expected to continue, though at a slower rate after 1980, resulting in a net loss of over 3 million oil heated homes by 1980 and another 2 million by 2000. Five million households heated by coal as well as nearly 2 million using LPG will be lost to other fuels or electricity by the year 2000. Both oil and coal are more frequently used in older homes, many of which will be replaced by 1980 and 2000. Although central oil heating systems will still be installed, gas and electricity are likely to take most of the replacement market. Convenience rather than cost has always beeen a more important determinant in the choice of an energy source in the residential market.

With the exception of ranges, water heaters, and clothes dryers, all household energy requirements were assumed to be provided by electricity. The nonspaceheating use of oil was estimated at 25 percent of spaceheating use.

The percentage shares of water heaters and ranges using gas did not increase as rapidly from 1960-65 as was implied by the RFF trends for 1960-70. Lower shares than those projected by RFF have therefore been projected for 1980 and 2000. LPG is estimated to have a 20-percent and a 10-percent share, respectively, of these two gas markets in 1980 and 2000. No changes were made in RFF's projections of the percentage share of gas dryers or the estimated proportion of "other residential sales," since both were in line with recent trends.

Annual Energy Requirements for Each Appliance and Use

There is an almost total absence of data on the annual energy requirements for spaceheat and appliances. RFF's estimates were based on their earlier (1960) study [18], and on judgments about various estimates by the industry and others. Nothing has been published since the RFF study to invalidate or significantly change their estimates, and these were not changed in the present projections.

A decline in the unit energy consumption of most appliances was projected between 1965 and 2000, largely due to improved efficiency of operation, but also to the fact that the more appliances a household has, the more infrequently some of them are used.

The projected increase in spaceheat per household between 1960 and 1980 is a reflection of improved heating standards, which are expected to reach their optimum in 1980. The projected decline in requirements between 1980 and 2000 is the result of an anticipated improvement in standards of insulation.

Efficiency of Conversion of Spaceheat

The efficiency of spaceheating equipment determines the amount of energy required for household spaceheating. In converting fuel to heat, some loss occurs with all fuels; for example, if the annual heat requirement of a household is 60 million B.t.u.'s and the efficiency of the equipment is 80 percent, the household will use 75 million B.t.u.'s of fuel. The efficiencies of the various fuels estimated by RFF were used in this study.

Electricity is assumed to be 100 percent efficient (i.e., converted to its heat equivalent without loss), except where heat pumps are used. Because of their use of underground heat, heat pumps can produce more heat than they consume and can be said to have efficiencies well in excess of 100 percent. The overall efficiency for electricity depends, therefore, on the proportion of homes using heat pumps. The RFF estimates were used in the projections of this study because installations of heat pumps between 1960 and 1965 followed the trend estimated by RFF for the period 1960-80.

Commercial and Other Nonindustrial Consumption

Commercial consumption of energy includes consumption by all types of businesses (stores, services, offices) and apartment buildings. Other nonindustrial consumption includes street and highway lighting, other consumption by public authorities, and agricultural consumption.

Historical data on commercial and other nonindustrial consumption is limited to total sales and the number of customers for gas and electricity, and the sales of commercial grades of fuel oil. There is virtually no information available on the annual energy requirements of any of the major sectors of the commercial market.

RFF projections were based largely on relationships between the commercial and residential markets, which were more or less constant for many years until 1960. The same approach was used for the projections in this study, but because of the accelerated growth in the commercial market since 1960, many of the relationships were revised.

Since 1960 commercial sales of electricity and gas have grown much more rapidly than residential sales, primarily the result of increases in the number and size of offices, stores, and apartments. Projections of the number of white-collar jobs relative to blue-collar jobs by 1980 and 2000 indicated that the demand for office space will continue to grow. Because of this trend, growth in other sectors of the market, and such factors as improved lighting standards and air conditioning, it has been assumed that the growth rate of the commercial market will remain well above the residential rate through 2000.

As a result, the current projections of commercial and other nonresidential uses of energy are somewhat higher than those of RFF. (RFF projections for electricity and gas for 1970 were both exceeded by 1965.) The current projections are closer to the more recent estimates of commercial and other nonresidential electricity consumption in 1980 made by Electrical World [8]. The National Power Survey [12] estimates for the commercial market are about halfway between the projections of RFF and Electrical World, but in the light of recent trends they appear to be too low.

Following is a brief discussion of the variables that were considered in projecting the commercial and other nonindustrial consumption of energy:

The number of commercial customers. The total number of commercial consumers of energy was assumed to be equal to the number of electricity customers.

Consumption of fuels per customer. Despite an increase in consumption per customer since 1960, a decline from 1965 levels was projected, mainly because of inroads into the fuels market by electricity.

Ratio of commercial to residential sales of gas. Until 1960 commercial consumption of gas averaged about 28 percent of residential consumption for a number of years, and RFF projected that it would remain at this level through 2000. From 1960-65, however, commercial sales increased much more rapidly than residential sales, and this trend was projected to continue. The commercial gas market is more cost-sensitive than the residential market and may not lose such a large proportion to electricity. The projections of a continued increase in the commercial-to-residential ratio were based on this factor plus the rapid overall growth of commercial consumption.

Number of commercial customers for electricity. The number of commercial customers averaged about 12 percent of the residential customers for about 20 years, until 1960. From 1960-65, the commercial-to-residential customer ratio increased to about 13 percent. It has been assumed that it will remain at about this level until 1980, but will increase to 15 percent by 2000.

Ratio of commercial consumption of electricity per customer and residential consumption per household. From 1945-60, this ratio declined and RFF projected that it would continue to do so. Since 1960, however, the more rapid growth of the commercial market has reversed this trend. It is assumed that the upward trend will continue.

Commercial electricity consumption per customer. This relationship is determined by residential consumption per household and the ratio of commercial consumption per customer to residential consumption per household.

Other nonindustrial gas sales. Following trends since 1960, other nonindustrial gas sales were projected as a declining percentage of commercial gas sales.

Electricity for streets and highways. This end use of electricity was projected on the basis of its relation to residential electricity consumption. Until 1960 there was a steady decline in the ratio, but since 1960 it has remained constant at slightly over 3 percent. With standards for streets and highway lighting continuing to improve, no further decline was projected.

Other public authority uses of electricity. Sales of electricity to public authorities for uses other than street and highway lighting remained between 12 and 13 percent of commercial sales for many years. From 1960-65, however, sales declined to 10.7 percent, possibly because of the rapid commercial growth. The consumption of electricity by public authorities was projected at 10 percent of commercial sales for both 1980 and 2000.

Electricity for agriculture. Projections were based on estimates of electricity requirements for irrigation and pumping that appeared in the National Power Survey [12].

Commercial coal consumption. Coal represents a very small part of the total commercial fuel market, and a continued decline was projected.

Commercial oil consumption. Oil consumption was treated as a residual, after estimates for the consumption of other fuels were subtracted from the total fuels market.

Industrial Consumption

The projections of the total consumption of energy by industry were aggregates of the projections of individual energy requirements for various industrial uses.

Projections of electric power consumption were based on the requirements of durable manufacturing industries (excluding primary metals); nondurable manufacturing; the steel industry (including electric furnace steel and ferro alloys); other metals (aluminum, copper, zinc, and magnesium); mining; and the Atomic Energy Commission which consumes a large amount of electric power in the processing of uranium.

Projections of fuels consumption were based on the requirements of the steel industry, nonferrous metals, petroleum refining, and "all other" manufacturing.

The approach, similar to the RFF approach, was to project an independent variable (e.g., Federal Reserve Board indexes of industrial production or tonnages of production) and to relate it to an estimate of unit energy requirements (e.g., B.t.u.'s or kilowatt hours consumed per point of the index or per ton). The total fuel requirement was then allocated among the fuels on a percentage basis and converted to physical quantities of fuel.

Electric Power Consumption by Industry

From 1950-65, the consumption of electric power per point in both the durable and nondurable FRB indexes of industrial production increased by about 20 percent, the result of growth in large power-consuming industries such as chemicals, replacement of fuels by electricity in some processes, and the need for more power-intensive processing in some industries. It was projected that, from 1965-80, electric power consumption per point of the durable goods index would increase to 820 million kilowatt hours, and for nondurable goods, to 1,600 million kilowatt hours per index point.[2] By 2000, consumption per point of the index was projected to have reached 960 kilowatt hours for durable goods and 1,760 for nondurable goods. The declining rate of increase after 1980 is expected to result from greater efficiency in the use of power per unit of output.

Projections of crude ingot steel production were derived from the projections of iron and steel shipments by assuming: (1) 85 percent of the iron and steel shipments would be from domestic production and 15 percent from imports in both 1980 and 2000, and (2) shipments from domestic production would be about 70 percent of crude ingot steel production. Imports have shown an upward trend in recent years, but it was assumed that, for reasons of national policy, they would not be allowed to rise above 15 percent by 1980 or 2000. The relationship between ingot steel output and domestic shipments of iron and steel was projected on the basis of the 1948-65 trends, which are expected to level off by 1980 and remain constant thereafter. It was also projected that 12 percent of steel production would be from electric furnaces in 1980, and 14 percent in 2000. From 1960-65 the steel produced from electric furnaces increased from 8.4 to 10.5 percent, and it was assumed that this trend would continue at a reduced rate.

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[2] Power consumption per point of the durable goods index during the 1960-65 period ranged from 660 to 700 million kilowatt hours, and of the nondurable goods index, from 1,347 to 1,407 million kilowatt hours.

Ferro alloy production in electric furnaces was projected by assuming: (1) total ferrous metallics requirements would be 10 percent higher than domestic shipments of iron and steel, (2) ferrous alloys would be 2 percent of total ferrous metallics requirements, and (3) 60 percent of the ferrous alloys would be produced in electric furnaces.

There is very little historical data on power consumption per ton of steel and nonferrous metals. The Bureau of the Census collects annual data for total steel production and data for some nonferrous metals every 4 or 5 years [20]. The RFF unit consumption estimates were based on the general trend indicated by the data that were available, and their projections were extrapolations of these trends. With the major exception of aluminum, it appeared from the limited information available since 1960 that the trends projected by RFF have generally been followed. Power consumption per ton of aluminum has not dropped as sharply as RFF projected, and a higher unit consumption has been estimated. For this reason, except for aluminum, the RFF unit consumption projections were used in this study.

Primary production indexes for aluminum, copper, magnesium, and zinc were obtained by: (1) Adjusting the RFF primary production index for each of the metals to correspond to the FRB durable manufacturing index projected in this study, and (2) projecting tonnages in relation to the indexes.

The consumption of power for other nonferrous metals production was projected in relation to the nonferrous production index.

For mining, projected power consumption per point of the FRB mining index is higher than that projected by RFF. The 1963 data indicated a more rapid increase in consumption per index point than was projected by RFF.

Consumption of power by the Atomic Energy Commission declined considerably between 1960 and 1965, with the decrease in uranium processing for nuclear weapons. It was projected, however, to remain at about the 1965 level through 2000.[3]

Fuels Consumption by Industry

Comprehensive data on the consumption of fuels by manufacturing industries (excluding primary metals and petroleum refining)are available from the Bureau of the Census at 4- to 5-year intervals only. On the basis of the 1935, 1947, 1954, and 1958 data, RFF estimated a declining trend for fuel consumption per index point of the FRB manufacturing index (excluding primary metals and petroleum refining). More recent data showed, however, that a slight increase occurred between 1958 and 1962. Fuel consumption per point of the manufacturing index was therefore projected to be about 10 to 15 percent higher than the RFF projections for 1980 and 2000. The higher figure also compensated for the fact that the total FRB manufacturing index was used as the independent variable in these projections since it was not possible to subtract the primary metals or petroleum refining components of the index. Primary metals have historically been lower than other components of the index.

No significant change in trends in the consumption of individual fuels was indicated by the 1962 Census data, and the RFF estimates of the percentage shares of each fuel were used.

Fuel consumption by the steel industry (excluding electric furnace steel) was measured by RFF on the basis of tons of coal equivalent required for each ton of steel produced. From the mid-forties until 1960, there was a steady decline in the trend, and RFF extrapolated the trend at more or less the same rate to 1980, and at a lower rate between 1980 and 2000. Implicit in this decline were improvements in technology and changes in the coke ratio. From 1960-65, coal equivalents required per ton of steel declined at approximately the rate projected by RFF. For this reason, the trends established by RFF were used in this study.

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[3] This assumption was made after discussions with the Atomic Energy Commission.

Data for the 1960-65 period indicate a somewhat greater use of gas in steel making and lesser use of oil than was implied in the RFF trend to 1980. The projected share for gas was therefore increased, and the share for oil reduced.

The 1962 data on fuel consumption for nonferrous metal production indicated a considerably lower consumption of fuels per nonferrous metals index point than was estimated by RFF in 1960. The RFF projections for 1980 and 2000 were, therefore, adjusted downward.

RFF estimated no change in the shares of individual fuels for nonferrous production between 1980 and 2000. However, a greater relative use of coal was indicated by the 1962 data, and this was accounted for in the projections.

The ratios between petroleum runs to stills and petroleum and natural gas consumption in refining have remained relatively constant for many years. The 1960 ratios were used by RFF in all projections and were also used in the projections provided by this study. Petroleum used for refining was estimated at 5.28 percent of total petroleum consumption, and natural gas at 3.84 percent of total consumption, converted at 6,000 cubic feet per barrel.

Fuel Requirements for Transportation

The projections of fuels required for transportation were based on projected annual mileages and miles per gallon of fuel for passenger cars, trucks, and buses. Total passenger car and truck mileages were derived from estimates of the growth in vehicle stock which, in turn, was related to the population and GNP and to the estimated annual mileages per vehicle. Increases in bus mileage were related to an index of growth for local, intercity, and school buses.

Passenger Cars

Projections of the number of passenger cars were based on the projections of the population aged 20 and over and the ratio of this population per vehicle. From 1930-60 this ratio declined at an average rate of 1.9 percent per year. The same annual rate of decline was projected to 1980. From 1980 to 2000 the ratio was projected to decline at 1.2 percent each year, resulting in a 1 to 1 relationship by 2000 (i.e., one passenger car per person aged 20 or over). This compares with a medium projection of 0.85 persons aged 20 or over per automobile by RFF.

Renewed interest in the electric car suggests that a small part of the market for second and third family cars might be supplied by electrically powered vehicles in the future. A projection of 0.5 to 1.5 million electric cars by 1980, and 1.5 to 3.5 million by 2000, was made. This is comparable to a recent estimate by the Federal Power Commission of 1.5 to 2.0 million by 1980 [9].

Annual mileages traveled per vehicle have remained between 9,700 and 10,000 miles since 1950. The RFF projection of 9,800 miles was used for 1980 and 2000.

The number of miles traveled per gallon of fuel from 1954 to 1965 ranged from 14.2 to 14.6 miles. Larger cars have tended to offset improvements in efficiency. The RFF projection of 14.5 miles per gallon has been used for 1980 and 2000.

Trucks

Projections of the total stock of trucks were related to growth in the GNP output of goods and structures. The dollar value of goods and structures per truck has increased in recent years and this trend is projected to continue, although at a slower rate than in the past.

Annual truck mileages ranged from 10,400 to 11,400 miles between 1950 and 1964. The RFF projection of 10,900 was used for both 1980 and 2000.

on those that appeared in the FPC National Power Survey in 1964, updated to account for any changes in plans that have occurred since then. For example, the Bridge Canyon project on the upper Colorado River, which could have supplied 5.4 billion kilowatt hours, has now been shelved.

No estimates have been made by the FPC of capacity to be installed after 1980, and our 25-percent figure is essentially a judgment of the approximate amount of remaining hydro capacity that might still be economically installed after 1980. The resulting hydro generation estimate is, however, only a little below the RFF estimate for 2000.

Nuclear generation in 1980 and 2000 was based on the latest estimates of the Atomic Energy Commission. AEC has estimated that by 1980 the amount of nuclear capacity installed will range from 120,000 MW to 170,000 MW, of which 58,000 MW has already been scheduled [5]. This range was not related directly to a range in total generation requirements. In the projections presented in this study, a figure of 145,000 MW was used as the most likely capacity to be installed. A load factor of 70 percent was assumed. For 2000, the AEC estimated that about 56 percent of the steam capacity would be nuclear [4]. This figure, adjusted downward slightly to account for internal combustion, was applied to the low, medium, and high estimates of generation in 2000 to obtain a nuclear generation estimate.

The resulting generation estimates for nuclear power were considerably higher than RFF estimates, which were made at a time when only one or two utilities were committed to anything more than small experimental units. Since 1963, however, nuclear power has become "accepted," and over 50,000 MW of nuclear capacity has been scheduled by utilities, most of it in units ranging from 500 to 1000 MW. The remaining generation was allocated to the conventional sources of fuel, natural gas, oil, and coal.

Generation from each fuel was projected as a percentage of the total conventional generation. Coal's share of 71 percent in 1980 and 77 percent in 2000 was larger than the RFF projections because of the expected continued improvement in coal's competitive position following further development of minemouth plants, long-distance transmission, and unit trains. Estimates of the shares of natural gas and oil were consequently slightly lower than those of RFF. Although more stringent air pollution regulations may come into effect, their long-run impact on coal consumption will probably be minor. Within the next few years, economic means of preventing emission of sulfur and other pollutants into the atmosphere from burning coal will undoubtedly become available.

Moreover, any substantial increase in the amount of residual fuel oil available would require a change in the present policy of import quotas. Similarly, greater use of natural gas for boiler fuel outside the producing States would require a change in regulatory policies relating to the interstate movement of natural gas. Hitherto, only very limited quantities of natural gas have been available to utilities for boiler fuel on a firm basis in the nonproducing States.

The fuel rates determine the actual amount of each fuel required, and fuel rates depend on the type and quality of the fuel used as well as the heat rate. RFF fuel rates were used in these estimates, since they are more or less in line with the 1960-65 trends. The projected decline in all fuel rates is due to a continued improvement in the heat rates.4/ The estimated heat rate for coal plants is 7,500 B.t.u. per kilowatt hour in 2000. Currently, the most efficient coal plants have a heat rate of a little over 8,000 B.t.u. per kilowatt hour, and the average in 1965 for all coal plants was 10,200, compared with 11,250 in 1956.

The actual amount of fuel used was obtained by applying the fuel rate to the generation estimates.

Other Consumption of Fuels

In order to obtain projections of the total consumption of coal, oil, natural gas, and natural gas liquids, projections were made of all other end uses of each fuel.

Natural Gas

Uses of natural gas were projected as follows:

4/ The number of B.t.u.'s required to generate 1 kilowatt-hour of electricity.

Until 1960, the number of miles traveled per gallon of fuel declined, and RFF projected that this trend would continue. From 1960 to 1965, however, there was an increase from 7.9 to 8.5 miles per gallon, and a higher ratio was therefore used in these projections.

Buses

Indexes were projected for interurban buses, local commercial buses, and school buses. The index for interurban buses is based on the ratio between passenger miles traveled and population. Since 1960 the number of passenger miles traveled has increased per person, and this upward trend was projected to continue until 1980 and to decline thereafter. The index for local commercial buses is based on the number of passengers carried. From 1960-65 there was a decline, but it was assumed that the trend would be upward between 1965 and 1980 because of greater urban densities in the future. The index for school buses is based on the number of school children traveling by bus. It was assumed that 85 percent of the population between the ages of 5 and 19 would be enrolled in schools (the level for many years), and that 45 percent in 1980 and 50 percent in 2000 would be carried by bus.

Bus mileages were projected in direct relation to a total weighted index (the RFF weights were used: interurban equals 30; local equals 45; and school equals 25). Mileages traveled per gallon were assumed to remain at the 1960 level through 2000.

The RFF projections of oil consumption by railroads and for shipping were used in this study.

"Other" consumption, which includes aviation fuel, pipeline fuel, and oil consumption by inland and coastal shipping, was projected on the basis of the relationship with the total for all other uses for transportation. The 1960 relationship was projected by RFF to remain constant through 2000. However, because of the rapid growth in the use of jet fuel, "other" consumption increased from 6.5 percent of the total in 1960 to 7.4 percent in 1965. To allow for probable future increases in the use of jets for passenger and freight movements, "other" consumption was estimated at 8.5 percent of total specified used in 1980 and 10.0 percent in 2000.

Electric Power Generation by Source of Energy

The projections for the generation of electric power were obtained by totaling the projections for residential, commercial, and industrial consumption. "Other" uses of electricity were projected at 8 percent of specified uses in 1980 and 10 percent in 2000.

Self-generation by industry was projected at 14 percent of total industrial consumption in 1980 and 10 percent in 2000. The RFF estimates were used since they were in line with the 1960-65 trend. Moreover, they resulted in a medium projection of 139 billion kilowatt hours in 1980, compared with the National Power Survey estimate of 127 billion kilowatt hours [12].

Self-generation by industry was subtracted from the projections of total generation to obtain a projection of utility sales.

Losses were estimated at 10 percent of utility sales in both 1980 and 2000. This is somewhat lower than the RFF estimate, which was based on a statistical series that has since been revised. From 1960-65, losses remained at about 10 percent of utility sales. No further decline was projected since it was assumed that any reduction in losses resulting from higher density markets would be offset by greater use of long-distance transmission. Losses are applied only to utility sales, since self-generated power is generally not transmitted any distance. The FPC National Power Survey also used a figure of 10 percent for losses.

Hydro power estimates were obtained as follows: 1980 -- the sum of the annual average generation expected from all hydro capacity installed by January 1, 1964, and all capacity already installed or expected to be installed from 1964-80; 2000 -- the 1980 estimate plus 25 percent of the annual average generation from all capacity remaining undeveloped after 1980.

The estimated annual average generation of all developed and undeveloped hydro capacity in the United States is published by the Federal Power Commission [11]. The estimates of capacity to be installed between 1964 and 1980 were based

Carbon black. Estimated at 12 and 10 billion cubic feet in 1980 and 2000, respectively.

Pipeline fuel. Estimated at 3.5 percent of all other specified end uses of gas (residential, commercial, industrial, electric generation, carbon black).

Transmission losses. Estimated at 2.5 percent of all specified end uses, plus pipeline fuel.

Field use. Estimated at 10 percent of all specified end uses, plus pipeline fuel.

Wasted and vented. Estimated at 3 percent of all specified end uses, plus pipeline fuel.

Natural gas liquids originating in natural gas processing. Natural gasoline plus 70 percent of natural gas liquid demand, converted at 1,343 cubic feet of gas per barrel.

The estimate for carbon black and the estimated percentage shares of pipeline fuel, transmission losses, field use, wasted and vented, and the percentage of natural gas liquids originating in gas processing are those used by RFF in their study.

Petroleum

The projections of oil consumption for defense, agriculture, and asphalt and road oil were based on RFF projections. Miscellaneous uses of oil were estimated at 5 percent of all other uses. Liquid refinery gas was estimated at 30 percent of natural gas liquids demand. That part of the gasoline market supplied by natural gasoline (all assumed to originate in natural gas) was subtracted from the consumption of oil.

Natural Gas Liquids

The RFF projections of natural gas liquids for agriculture, industry, and motor fuels were also used. Natural gasoline was projected to increase at the same rate as natural gas.

Coal

Exports of coal were projected at 70 million tons in 1980 and 100 million in 2000. This projection was based primarily on the assumption that the demand for U.S. metallurgical coal from foreign steel producers would continue to grow. It was assumed that the railroads would use no coal in 1980 and 2000.

Electric Power Generation by Region and State

The trend in the per capita consumption of electricity[5] in each region was determined for the 1950-65 period and extrapolated to 1980 and 2000. It was assumed that variations in per capita consumption between the regions would decrease as regional advantages and disadvantages affecting the level of consumption diminish. For example, in 1965 per capita consumption ranged from 17 percent above the national average in the South to 37 percent below the national in the Northeast. By 2000 it was estimated that per capita consumption in the South would be only about 3 percent above the national average and that per capita consumption in the Northeast would be only 5 percent below the national average.

The per capita estimates for each region were multiplied by the medium population projections for 1980 and 2000 to obtain the medium generation requirement for each region.

The low and high generation requirements for each region were obtained by applying each region's percentage share of the national medium generation projection to the high and low generation projections for the Nation. For example, by multiplying the per capita consumption projections for the Northeast by the medium population projection for the Northeast, a medium generation estimate of 561 billion kilowatt hours was obtained for 1980. This is 20.2 percent of the medium generation estimate for the United States in 1980. The low and high estimates for the Northeast were therefore projected to be 20.2 percent of the high and low national projections.

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[5] Obtained by dividing electricity generated by population.

This method was employed because the share of each region's population as a percentage of the total national population in 1980 and 2000 was the same for the low, medium, and high projections, and it was assumed that their shares of generation requirements would also be the same.

Table 116. Residential Consumption of Fuels and Electricity by Type of Use, 1960 and 1965, and Projected 1980 and 2000

Item	1960	1965	1980			2000		
			Low	Medium	High	Low	Medium	High
Gas (trillion B.t.u.)								
Spaceheating	2,170	2,671	3,588	3,653	3,716	3,112	3,296	3,514
Ranges	260	282	274	278	283	244	258	276
Water heaters	527	632	882	897	913	849	898	962
Clothes dryers	13	20	84	85	87	118	125	134
Other uses	218	397	851	866	880	804	854	931
Total	3,188	4,002	5,679	5,779	5,879	5,127	5,431	5,817
LPG (trillion B.t.u.)								
Spaceheating	145	184	241	245	250	84	89	95
Ranges	65	70	68	70	71	60	64	69
Water heaters	58	70	98	100	102	94	100	107
Total	268	324	407	415	423	238	253	271
Oil (trillion B.t.u.)								
Spaceheating	2,110	2,105	1,622	1,651	1,680	1,077	1,140	1,215
Non-spaceheating	528	526	406	414	420	290	310	339
Total	2,638	2,631	2,028	2,065	2,100	1,367	1,450	1,554
Coal (trillion B.t.u.)a/	530	359	156	159	161	--	--	--
Total fuel (trillion B.t.u.)	6,624	7,316	8,269	8,418	8,563	6,732	7,134	7,642
Physical Units:b/								
Gas (billion cu. ft.)	3,080	3,867	5,487	5,584	5,680	4,954	5,247	5,620
LPG (million bbls.)	68	81	101	103	105	59	63	66
Oil (million bbls.)	463	462	356	362	368	240	254	273
Coal (million tons)	20	14	6	6	6	--	--	--
Electricity (billion kw.-hr.)								
Spaceheating	12	36	161	164	166	316	334	360
Air conditioning	9	22	72	73	74	140	148	158
Ranges	21	28	51	52	53	58	62	66
Water heaters	45	62	128	130	133	233	247	257
Television and refrigerators	28	33	45	46	46	56	59	64
Freezers	9	12	27	27	28	46	49	53
Dryers	9	12	23	23	24	34	36	38
Lighting	43	55	99	101	102	171	181	193
Miscellaneous	17	26	64	65	66	150	158	170
Total electricity	194	288	670	681	692	1,204	1,273	1,359

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a/ Includes anthracite.

b/ Converted as follows: Coal = 26.2 million B.t.u./ton; Gas = 1,035 B.t.u./cu.ft.; Oil = 5.7 million B.t.u./bbl.; and LPG - 4,011,000 B.t.u./bbl.

Sources: 1960 data from [16]. 1965 data from [1, 6, 13, 14] and unpublished data from the (Electric) Heating Association, Inc.

Table 117. Variables Used in Estimating Residential Consumption of Energy, Number of Households, Saturation Factors, and Type of Use, by Energy Source and Annual Energy Requirement, 1960 and 1965, and Projected 1980 and 2000

Item	1960	1965a/	1980	2000
Households (millions)				
Low	52.6	57.5	74.7	93.6
Medium			76.0	99.0
High			77.3	106.0
Saturation factor (percent)				
Air conditioning				
Room	0.9	5.2	20	50
Central	14.0	27.1	45	40
Ranges	105.0	104.7	116	120
Water heaters	60.9	70.1	67	100
Refrigerators	95.2	98.1	100	100
Television	87.1	93.9	100	100
Lighting	100.0	100.0	100	100
Freezers	22.1	23.5	40	55
Dryers	18.3	25.0	56	72
Miscellaneous	100.0	100.0	100	100
Appliances by energy source (percent)				
Ranges				
Electric	34.4	39.0	54	65
Gas/LPG	65.6	41.0	46	35
Water heaters				
Electric	29.9	33.0	42	58
Gas/LPG	70.1	67.0	58	42
Dryers				
Electric	70.0	67.6	50	50
Gas	30.0	32.4	50	50
All others - electric	100.0	100.0	100	100
Annual requirement				
Air conditioning - electric (kw.-hr.)				
Room	800	775	700	600
Central	3,500	3,425	3,200	2,500
Ranges				
Electric (kw.-hr.)	1,200	1,200	1,100	800
Gas (thousand B.t.u.)	9,600	9,600	8,575	7,750
Water heaters				
Electric (kw.-hr.)	4,700	4,700	4,700	4,300
Gas (million B.t.u.)	26	26	26	24
Refrigerators - electric (kw.-hr.)	300	300	300	300
Television - electric (kw.-hr.)	300	300	300	300
Lighting - electric (kw.-hr.)	825	950	1,325	1,825
Freezers - electric (kw.-hr.)	800	825	900	900
Dryers				
Electric (kw.-hr.)	1,300	1,250	1,100	1,000
Gas (thousand B.t.u.)	4,500	4,125	4,000	3,500
Miscellaneous - electric (kw.-hr.)	330	460	850	1,600

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a/ As of July 1. Annual energy requirement obtained by interpolation on the 1960-80 trend.

Source: 1960 data from [16]. 1965 data from [1, 6, 13, 14] and unpublished data from the (electric) Heating Association, Inc.

Table 118. Variables Used in Estimating Residential Consumption of Energy for Spaceheating, 1960 and 1965, and Projected 1980 and 2000

Item	1960	1965a/	1980	2000
Households (millions)				
Low	52.6	57.5	74.7	93.6
Medium			76.0	99.0
High			77.3	106.0
Spaceheat				
Electric homes:				
Percent	1.7	4.5	18.0	40.0
Number (millions)				
Low	0.9	2.6	13.5	37.5
Medium			13.7	39.6
High			13.9	42.7
Nonelectric homes:				
Number (millions)				
Low	51.7	54.9	61.2	56.1
Medium			62.3	59.4
High			63.4	63.3
Percent				
Gas	48.6	55.1	67.0	74.0
Oil	38.6	36.1	26.5	24.0
Coal	8.4	5.0	2.0	--
LPG	4.4	3.8	4.5	2.0
Annual Heat Output per Household				
Electricity (thousand kw.-hr.)	14.0	14.0	16.0	16.0
Fuel (million B.t.u.)	65.7	68.0	70.0	60.0
Efficiency				
Electric	110	116	134	190
Gas/LPG	76	77	80	80
Oil	62	64	70	75
Coal	51	52	55	55

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a/ As of July 1. Annual heat output and efficiencies obtained by interpolation of the 1960-80 trend.

Source: 1960 data from [16]. 1965 data from [1, 6, 13, 14] and unpublished data from the (Electric) Heating Association, Inc.

Table 119. Variables Used in Estimating Commercial and Other Nonindustrial Consumption of Fuels and Electricity, 1960 and 1965, and Projected 1980 and 2000

Fuel Consumption	1960	1965	1980	2000
Commercial:				
Total fuel consumption				
Number of customers (thousands)				
Low			9.7	14.0
Medium	6.5	7.4	9.9	14.8
High			10.0	15.9
Consumption per customer (million B.t.u.)	362	380	360	320
Gas				
Commercial as a percent of residential gas sales	28.9	33.6	38.0	50.0
Electricity				
Customers as a percent of households	12.3	12.9	13.0	15.0
Ratio, commercial to residential consumption per customer	4.45	5.58	6.5	7.5
Consumption per customer (kw.-hr.)	17,100	27,472	58,240	96,450
Nonindustrial:				
Gas				
Other sales as percent of commercial	51.1	36.6	40.0	35.0
Electricity				
Streets and highways as percent of residential consumption	3.1	3.1	3.0	3.0
Other public authorities as a percent of commercial consumption	13.6	10.7	10.0	10.0

Source: 1960 data from [16]. 1965 data from [1, 7, 24].

Table 120. Commercial and Other Nonindustrial Consumption of Fuels and Electricity, 1960 and 1965 and Projections to 1980 and 2000

Fuel consumption	1960	1965	1980			2000		
			Low	Medium	High	Low	Medium	High
Commercial:								
Fuel consumption (trillion B.t.u.)								
Gas....................	920	1,346	2,158	2,196	2,234	2,564	2,716	2,909
Coal....................	600	400	100	225	300	100	200	300
Oil....................	840	889	1,084	993	916	1,641	1,645	1,704
LPG....................	80	120	150	150	150	175	175	175
Total fuel................	2,440	2,755	3,492	3,564	3,600	4,480	4,736	5,088
Physical quantities								
Gas (billion cu. ft.)....	889	1,300	2,085	2,122	2,158	2,477	2,624	2,811
Coal (million tons)......	23	15	4	9	11	4	8	11
Oil (million bbls.)......	138	143	175	160	148	263	265	275
LPG (million bbls.)......	20	30	37	37	37	44	44	44
Electricity								
Total (billion kw.-hr.)....	113	202	565	577	582	1,350	1,427	1,534
Other nonindustrial:								
Gas								
Total (trillion B.t.u.)....	486	509	863	878	894	897	951	1,018
Total (billion cu. ft.)....	470	492	834	848	864	867	919	984
Electricity (billion kw.-hr.)								
Streets and highways.......	6.1	8.8	20.0	20.4	20.8	36.1	38.2	40.8
Other public authorities...	15.6	21.7	56.5	57.7	58.2	135.0	142.7	153.4
Agriculture...............	10.0	13.7	25.0	25.0	25.0	35.0	35.0	35.0
Total....................	31.7	44.2	101.5	103.1	104.0	206.1	215.9	229.2

Source: 1960 data from [16]. 1965 data from [1, 7, 24].

Table 121. Variables Used in Estimating Consumption of Electric Power by Manufacturing Industries, Mining and the Atomic Energy Commission, 1960 and 1965 and Projected 1980 and 2000

Item	1960	1965	1980			2000		
			Low	Medium	High	Low	Medium	High
Manufacturing:[a]								
Durables								
FRB index..............	108.5	148.4	283.6[d]	309.2[d]	318.1[d]	517.3[d]	612.2[d]	677.0[d]
Consumption per index point (million kw.-hr.)	660	669	820	820	820	940	940	940
Nondurables								
FRB index..............	109.5	140.8	258.3	281.8	290.0	492.1	582.4	644.1
Consumption per index point (million kw.-hr.)	1,347	1,403	1,600	1,600	1,600	1,760	1,760	1,760
Steel:								
Production (million tons)								
Electric furnace.......	8.4	13.8	36.7	38.1	39.1	72.6	78.5	93.2
Ferro alloys in electric furnaces..............	1.25	2.10	2.8	2.9	3.0	4.8	5.2	6.1
All other steel........	90.9	117.7	269.0	279.8	286.4	445.9	482.2	572.2
Power consumed kw.-hr. per ton								
Electric furnaces......	700	675[b]	600	600	600	500	500	500
Ferro alloys in electric furnaces..............	6,000	5,750[b]	5,000	5,000	5,000	4,250	4,250	4,250
Other steel...........	200	215[b]	265	265	265	350	350	350
Nonferrous metals:								
Aluminum production (Million tons)........	2.01	2.65	4.4	5.4	7.1	5.5	9.9	13.9
Kw.-hr. per ton.......	18,100	18,000	16,400	16,400	16,400	15,500	15,500	15,500
Magnesium (Thousand tons).......	40	81	32	39	52	26	48	66
Kw.-hr. per ton.......	19,000	18,200[b]	16,200	16,200	16,200	15,000	15,000	15,000
Copper (Million tons)........	1.55	1.71	1.59	1.95	2.08	0.99	2.70	3.73
Kw.-hr. per ton.......	2,100	2,150	2,300	2,300	2,300	2,500	2,500	2,500
Zinc (Million tons)........	.82	.99	.93	.97	1.06	.90	1.38	1.85
Kw.-hr. per ton.......	2,200	2,300[b]	2,600	2,600	2,600	3,000	3,000	3,000
Other non ferrous processing (billion kw.-hr.)	2.00	2.38	4.36	5.12	6.22	5.40	9.38	10.26
Mining:								
FRB index..............	87	108[c]	149.3	163.2	167.9	304.8	360.5	398.4
Consumption per index point (million kw.-hr.)	170	208[c]	220	220	220	240	240	240
Atomic Energy Commission (billion kw.-hr.)................	60	38	30	35	40	30	35	40

---

a/ Excludes primary metals and power consumed by the Atomic Energy Commission.
b/ Obtained by interpolation on the 1960-80 trend line.
c/ 1963 data.
d/ Includes primary metals and petroleum refining.

Source: 1960 data from [16]. 1965 data from [2, 8, 19, 21, 24].

by Manufacturing Industries, 1960 and 1965, and Projected 1980 and 2000

Item	1960	1965	1980			2000		
			Low	Medium	High	Low	Medium	High
Manufacturing:[a]								
FRB index of manufacturing	110.0	120.1[b]	272.6[e]	297.3[e]	305.9[e]	506.0[e]	598.7[e]	662.1[e]
Fuels consumed per index point (trillion B.t.u.)	45.0	46.8[b]	38	38	38	30	30	30
Fuels consumed (trillion B.t.u.)	4,950	5,620[b]	10,359	11,297	11,624	19,228	22,751	25,160
Fuel shares (percent)								
Coal	36	35[b,c]	23	23	23	15	15	15
Natural gas	46	45	62	62	62	70	70	70
Oil	18	15	15	15	15	15	15	15
Steel:								
Steel production, excluding electric furnace (million tons)	90.9	117.7	269.0	279.8	286.4	445.0	482.2	572.2
Coal equivalent per ingot ton[d]	1.082	1.008	.800	.800	.800	.700	.700	.700
Fuel consumed (millions of tons of coal equivalent)	102.9	122.9	215.2	223.8	229.1	356.7	385.8	457.8
Fuel shares (percent)								
Coal	76	74	70	70	70	66	66	66
Oil	10	8	8	8	8	8	8	8
Natural gas	14	18	22	22	22	26	26	26
Nonferrous metals:								
Index of production	100.0	119.1[b]	218	256	311	270	469	513
Fuels consumed per index point (trillion B.t.u.)[d]	2.50	2.09[b]	1.85	1.85	1.85	1.60	1.60	1.60
Fuels consumed (trillion B.t.u.)	250	249[b]	403	474	575	432	750	821
Fuel shares (percent)								
Coal	30	39[b]	40	40	40	40	40	40
Natural gas	50	44	45	45	45	45	45	45
Oil	20	17	15	15	15	15	15	15
Petroleum refining:								
Petroleum for refining (million bbls.)	165	193	250	276	314	391	460	580
Natural gas for refining (trillion cu. ft.)	.72	.84	1.09	1.21	1.37	1.71	2.00	2.53

---

a/ Excludes primary metals, and petroleum refining.
b/ 1962 data.
c/ Five percent of fuel unaccounted for.
d/ Excludes fuel consumed to generate electricity.
e/ Includes primary metals and petroleum refining.

Source: 1960 data from [16]. 1965 data from [2, 19, 20, 24].

Table 123. Consumption of Fuel and Electric Power, by Industry 1960 and 1965, and Projected 1980 and 2000

Item	1960	1965	1980			2000		
			Low	Medium	High	Low	Medium	High
Coal (trillion B.t.u.)								
All manufacturing[a].....	1,760	1,980[b]	2,383	2,598	2,674	2,884	3,413	3,774
Steel..................	2,062	2,392	3,946	4,106	4,202	6,167	6,671	7,915
Nonferrous.............	75	114[b]	163	190	230	173	300	328
Total................	3,897	4,486	6,492	6,894	7,106	9,224	10,384	12,017
Gas (trillion B.t.u.)								
All manufacturing[a].....	2,250	3,116[b]	6,423	7,004	7,207	13,460	15,926	17,612
Steel..................	375	566	1,239	1,289	1,320	2,429	2,628	3,118
Nonferrous.............	125	135[b]	181	213	259	194	338	369
Petroleum refining......	745	872[c]	1,138	1,252	1,428	1,780	2,090	2,629
Total................	3,495	4,689	8,981	9,758	10,214	17,863	20,982	23,728
Oil (trillion B.t.u.)								
All manufacturing[a].....	880	972[b]	1,554	1,695	1,744	2,884	3,413	3,774
Steel..................	259	244	451	469	479	747	810	959
Nonferrous.............	50	51[b]	60	71	86	65	113	123
Petroleum refining......	1,040	1,216[c]	1,588	1,751	1,991	2,482	2,917	3,679
Total................	2,229	2,483	3,653	3,986	4,300	6,178	7,253	8,535
Physical units[e]								
Coal (million tons)....	149	171	248	263	271	352	396	458
Gas (billion cu.ft.)....	3,376	4,530	8,677	9,428	9,868	17,259	20,272	22,925
Oil (million bbls.).....	353	394	580	633	882	980	1,151	1,355
Electricity (billion kw.-hr.)								
All manufacturing[a].....	219	297	646	704	725	1,352	1,600	1,770
Steel..................	30	40	107	112	114	213	230	273
Nonferrous.............	46	58	82	104	134	101	181	250
Mining.................	16	24[b]	33	36	37	73	86	96
Other[d]................	50	38	30	35	40	30	35	40
Total................	373	457	898	991	1,050	1,769	2,132	2,429

---

a/ Excludes primary metals, petroleum refining, and consumption by the Atomic Energy Commission.

b/ Interpolated from 1962 or 1963 data and the 1980 medium estimate.

c/ Estimated using 1960 ratio of gas consumed in petroleum refining to petroleum demand, and converted at 6,000 cu.ft. per barrel.

d/ Atomic Energy Commission.

e/ Converted at 26.2 million B.t.u. per ton of coal.
1,035 B.t.u. per cubic foot of gas.
6.3 million B.t.u. per barrel of oil.

Source: 1960 data from [16]. 1965 data from [2, 8, 19, 20, 21, 24].

Table 124. Fuel Requirements for Transportation, 1960 and 1965, and Projected 1980 and 2000

Item	1960	1965	1980			2000		
			Low	Medium	High	Low	Medium	High
Passenger cars								
Total stock (millions)........	59.3	72.0	113.3	118.7	136.0	170.5	194.9	229.3
Population age 20 and over per vehicle............	1.86	1.63	1.10	1.26	1.32	0.90	1.00	1.10
Electric cars (millions)......	--	--	0.5	1.0	1.5	1.5	2.5	3.5
Fuel-consuming cars (million).	59.3	72.0	112.8	117.7	134.5	169.0	192.4	225.8
Miles per vehicle (thousand)..	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8
Passenger car miles (billion).	588	709	1,105	1,153	1,318	1,656	1,886	2,213
Miles per gallon..............	14.3	14.3	14.5	14.5	14.5	14.5	14.5	14.5
Total fuel consumed (million bbls.)..............	981	1,183	1,814	1,893	2,164	2,719	3,095	3,632
Trucks								
Total stock (millions)........	11.6	14.0	22.2	24.2	24.9	47.6	50.5	55.9
GNP output of goods and structures (dol. billion)....	315	419	733	800	823	1,666	1,769	1,957
Ratio of stock/GNP goods and structures (dol. billion)....	27.1	30.0	33.0	33.0	33.0	35.0	35.0	35.0
Miles per vehicle (thousands).	10.9	12.4	10.9	10.9	10.9	10.9	10.9	10.9
Truck-miles (millions)........	126	174	242	264	271	519	550	609
Miles per gallon..............	7.9	8.5	7.5	7.5	7.5	7.5	7.5	7.5
Total fuel consumed (million bbls.)..............	379	488	768	838	860	1,648	1,746	1,933
Buses								
Index of growth...............	100	102	111	126	144	140	160	177
Interurban..................	100	114	100	125	150	95	110	125
Local commercial............	100	83	100	110	125	125	135	150
School......................	100	120	145	156	172	202	236	289
Bus-miles.....................	4.4	4.7	4.9	5.5	6.3	6.2	7.0	7.8
Fuel consumed (million bbls.)......................	20	21	22	25	28	28	31	35

Source: 1960 data from [16]. 1965 data from [3, 17, 25].

Table 125. Fuel Requirements for Transportation, 1960 and 1965 and Projected 1980 and 2000

(Million barrels)

Mode	1960	1965	1980			2000		
			Low	Medium	High	Low	Medium	High
Passenger cars.....	981	1,183	1,814	1,893	2,164	2,719	3,095	3,632
Trucks............	379	488	768	838	860	1,648	1,746	1,933
Buses.............	20	21	22	25	28	28	31	35
Railroads..........	90	91	80	130	200	90	200	420
Marine............	80	57	190	210	270	360	450	760
Other[a/]...........	100	155	244	263	299	485	552	678
Total.............	1,650	2,095	3,118	3,359	3,821	5,330	6,074	7,458

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a/ Includes aviation, inland and coastal shipping and oil pipeline use.

Source: 1960 data from [16]. 1965 data from [15, 24, 25].

Table 126. Consumption and Generation of Electricity, 1960 and 1965 and Projected 1980 and 2000

(Billion kilowatt hours)

Item	1960	1965	1980			2000		
			Low	Medium	High	Low	Medium	High
Total specified uses.....	711	991	2,235	2,352	2,428	4,529	5,048	5,551
Other..................	42	68	179	188	194	453	505	551
Total all end uses.....	753	1,059	2,414	2,540	2,622	4,982	5,553	6,102
Total industry use.......	373	457	898	991	1,050	1,759	2,132	2,429
Self-generation as percent of industry use...	23.6	22.3	14	14	14	10	10	10
Self-generation.........	88	102	126	139	147	177	213	243
Utility sales...........	684[a/]	957	2,288	2,401	2,475	4,805	5,340	5,859
Losses as percent of utility sales..........	10[a/]	10.2	10	10	10	10	10	10
Amount of losses.........	69[a/]	98	229	240	248	481	534	586
Generation requirements..	845	1,157	2,643	2,780	2,870	5,463	6,087	6,688

---

a/ Adjusted since RFF estimates were made.

Source: 1960 data from [162. 1965 data from [1, 2, 6, 7, 8, 10, 13, 14, 19, 20, 21, 24].

Table 127. Electricity Generation by Source of Energy, 1960 and 1965, and Projected 1980 and 2000

(billion kilowatt hours)

Item	1960	1965	1980			2000		
			Low	Medium	High	Low	Medium	High
Total Generation	845	1,157	2,643	2,780	2,870	5,463	6,087	6,688
Nuclear	-	4	893	893	893	2,730	3,059	3,377
Hydro	149	197	305	305	305	343	343	343
Thermal conventional	696	956	1,445	1,582	1,672	2,390	2,685	2,968
Natural Gas								
Percent share of conventional thermal	26.0	25.8	24.0	24.0	24.0	20.0	20.0	20.0
Generation	181	247	347	380	401	478	537	594
Fuel rate (cu. ft. per thousand kw.-hr.)	10,910	10,400	9,300	9,300	9,300	7,875	7,875	7,875
Amount used (billion cu. ft.)	2,034[a]	2,569	3,227	3,534	3,729	3,764	4,229	4,678
Oil								
Percent share of conventional thermal	7.6	7.6	5.0	5.0	5.0	3.0	3.0	3.0
Generation	53	73	72	79	84	72	81	89
Fuel rate (bbls. per thousand kw.-hr.)	1.85	1.76	1.58	1.58	1.58	1.36	1.36	1.36
Amount used (million bbls.)	101[a]	128	114	125	133	98	110	121
Coal								
Percent share of conventional thermal	66.4	66.5	71.0	71.0	71.0	77.0	77.0	77.0
Generation	461	636	1,026	1,123	1,187	1,840	2,067	2,285
Fuel rate (lbs. per kw.-hr.)	0.88	0.86	0.74	0.74	0.74	0.625	0.625	0.625
Amount used (million tons)	208[a]	273	380	425	439	575	636	714

---

a/ RFF adjusted the amounts of fuel used to account for a lower heat rate at nonutility plants.

Source: 1960 data from [16]. 1965 data from [7, 10].

Table 128. Other Consumption of Natural Gas, Petroleum, Natural Gas Liquids, and Coal, 1960 and 1965, and Projected 1980 and 2000

Item	1960	1965	1980			2000		
			Low	Medium	High	Low	Medium	High
Natural gas (trillion cu.ft.)								
Carbon black	.20	.10	.12	.12	.12	.10	.10	.10
Pipeline fuel	.36	.52	.72	.76	.79	1.03	1.17	1.30
Transmission losses	.26	.33	.53	.56	.59	.76	.87	.96
Field use (excl. NGL extraction loss)	1.32	1.67	2.13	2.25	2.35	3.06	3.47	3.85
Wasted and vented	.56	.31	.64	.67	.70	.92	1.04	1.16
Natural gas liquids originating in natural gas processing	.46	.59	.95	1.07	1.24	1.59	2.13	2.93
Other	.33[a]	-	-	-	-	-	-	-
Total	3.49	3.52	5.09	5.43	5.79	7.46	8.78	10.30
Petroleum (million bbls.)								
Defense	213	184[b]	99	267	430	99	335	716
Agriculture	128	131[b]	137	144	151	135	158	181
Asphalt and road oil	111	134	197	224	277	334	448	710
Miscellaneous	149	165[c]	227	250	288	356	418	526
Liquid refinery gas	78	91[d]	145	176	220	278	490	649
Total	679	705	815	1,061	1,366	1,202	1,849	2,784
Less: Natural gasoline originating in gas processing	185	230[d]	370	390	409	533	601	671
Natural gas liquids (million bbls.)								
Agriculture	12	14[b]	19	20	21	18	26	44
Industry	119	163[b]	297	397	539	742	1,336	1,945
Motor fuel	12	16[b]	29	29	29	63	63	63
Natural gasoline	185	230[b]	370	390	409	533	601	671
Less: Natural gas liquids originating in petroleum refining	78	91[d]	145	176	220	278	490	649
Coal (million tons)								
Exports	38	50	70	70	70	100	100	100
Railroads	3	1	-	-	-	-	-	-

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a/ Adjustment by RFF to make data agree with Bureau of Mines estimates.
b/ Interpolation from RFF 1960-70 trend.
c/ Estimated at 5 percent of identified uses.
d/ Estimated.

Source: 1960 data from [16]. 1965 data from [24].

APPENDIX TO CHAPTER VII

LUMBER, PANEL, AND WOODPULP PRODUCTS

Projections of the consumption of lumber veneer and plywood in 1980 and 2000 were based primarily on two recent studies by the Forest Service [3, 4] in which projections of demands were made for all types of wood products in 1980 and 2000. The approach in both studies was to relate unit consumption of wood products by the major end uses (residential construction, paper, etc.) to independent variables such as population, GNP, disposable personel income, and industrial output. These projections have been used as the basis for the projections in this study, adjusted to incorporate the independent variables and for somewhat different assumptions as to the rate of technological change and rate of substitution of nonwood products for wood.

Lumber, Veneer, and Plywood

Timber Trends [3] provided the basis for the projections of lumber and veneer and plywood. Historical data on the consumption of lumber and panel products by end use is very limited. For most end uses, the Forest Service estimates of total consumption and unit consumption were related to an independent variable for the base year, 1962, and, if possible, for one or two other postwar years. Since 1962, however, no estimates have been made of the consumption of lumber or panel products by end use.

In this study, trends in the independent variables used in Timber Trends since 1962 were examined and the Forest Service projections of these variables for 1980 and 2000 were adjusted in accord with recent developments. Projections of independent variables presented elsewhere in this study were used where relevant. For example, projections of the number of dwelling units (used to project residential consumption) are related to the number of households, which are, in turn, a function of the population projections.

Projections of lumber consumed per unit (per dwelling unit, per dollar of expenditure, etc.) were generally lower than those of the Forest Service in most end uses, primarily because a more rapid rate of substitution of nonlumber products and of panel products for lumber was assumed. Recent

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trends indicate much greater use of plastics and plywood than was indicated by Timber Trends, partly because of the tendency toward prefabriciation in some sectors. Conversely, the projections of unit consumption of veneer and plywood are somewhat higher than those of the Forest Service.

Woodpulp Products

The projections of the consumption of woodpulp products were based on a recent Forest Service study [4] in which projections were made for paper and board, all types of woodpulp, and pulpwood for 1970-85.

The Forest Service projections of the consumption of each type of paper and board for 1980 were related to various independent variables, such as gross national product and disposable personal income. These were adjusted to account for the higher GNP and DPI assumed in this study. For 2000, the Forest Service 1970-85 trends were extrapolated and adjusted to fit the projections of independent variables in this report.

Projections of the amount of woodpulp and other fibrous materials used in paper and board production and of the production of various types of woodpulp in 1980 were also based on the Forest Service projections. The 1970-85 trends were extrapolated to 2000.

Table 129. Households and Dwelling Units in the United States, 1950-66 and Projected 1980 and 2000

(in thousands)

Year	All dwelling units	Households	Vacant dwelling units
1950........	46,137	42,969	3,168
1960........	58,468	52,799	5 513
1961........	--	53,464	n.a.
1962........	--	54.652	n.a.
1963........	--	55,189	n.a.
1964........	--	55,996	n.a.
1965........	--	57,251	n.a.
1966........	--	58,092	n.a.
1980........	84,500	76,000	8,500[a]
2000........	110,000	99,000	11,000

---

a/ Vacancy rate assumed to be 10 percent.

Source: Historical data from [2].

Table 130. Dwelling Units Provided Per Year in the United States, 1950-66 and Projected 1980 and 2000

(in thousands)

Year	Total	Type of unit				
		One-family	Two-family	Multi-family	Mobile homes	Net additions by conversion
1950-59[a]	1,686.1	1,215.5	45.0	199.4	40.4	185.8
1960	--	1,008.8	50.5	236.8	98.0	n.a.
1961	--	989.3	50.0	326.1	86.0	n.a.
1962	--	996.3	56.1	440.2	112.0	n.a.
1963	--	n.a.	n.a.	n.a.	151.0	n.a.
1964	--	973.0	62.0	556.0	191.0	n.a.
1965	--	964.0	57.0	552.0	216.0	n.a.
1966	--	795.0	46.0	411.0	217.0	n.a.
1980	2,200.0	1,180.0	70.0	611.0	275.0	100.0
2000	2,500.0	1,225.0	75.0	850.0	250.0	100.0

---

[a] Annual average.

Source: Historical data from [3].

Table 131. Dwelling Units Provided Per Year, Increase and Replacements, 1950-65 and Projected 1980 and 2000

(in thousands)

Average per year	Total units provided	Increase in inventory	Replacements
1950-59.....	1686.1	1233.1	453.0
1960-65.....	1630.0 [a]	1180.0	450.0 [b]
1980........	2200.0	1295.0	905.0
2000........	2500.0	1245.0	1255.0

---

[a] Estimated from housing starts and mobile home sales.

[b] Estimated.

Source: Historical data from [2, 3].

Table 132. Wood Used Per Dwelling Unit, 1962 and Projected 1980 and 2000

Item	1962 (Actual)	1980	2000
Lumber (board feet)			
One- and two-family units	11,190	10,290	7.750
Multifamily units	4,500	4.050	3,000
Mobile homes	1,800	1,800	1,500
Veneer and plywood (square feet 3/8" basis)			
One- and two-family units	3,010	5,100	6,100
Multifamily units	1,800	2,100	2,400
Mobile homes	1,840	2,000	2,100

Source: 1962 data from [3].

Table 133. Expenditures for New Nonresidential Construction, 1950-65 and Projected 1980 and 2000

(billion dollars)

Year	Amount
1950-59[a/]	27.0
1960	32.1
1961	33.5
1962	33.9
1963	35.8
1964	38.5
1965	44.0
1980	52.7
2000	83.4

---

a/ Annual average.

Source: Historical data from [2].

Table 134. Lumber and Veneer and Plywood Consumed in Nonresidential Construction per Dollar of Construction Expenditure 1962 and Projected 1980 and 2000

Item	1962 (actual)	1980	2000
Lumber (board feet)	0.15	0.12	0.075
Veneer and plywood (square feet 3/8" basis)......	0.08	0.18	0.121

Source: 1962 data from [3].

Table 135. Expenditures and Consumption of Lumber, Veneer, and Plywood by Type of Use for Upkeep and Improvements 1962 and Projected 1980 and 2000

Item	1962	1980			2000		
		Low	Medium	High	Low	Medium	High
Expenditures (billion dollars)[a/]							
Residential	11.2	18.2	19.1	19.8	19.7	26.6	27.5
Nonresidential ...	12.6	17.8	18.7	19.1	20.5	27.8	28.7
Lumber							
Board feet per dollar expenditure	.227	.164	.164	.164	.120	.120	.120
Volume (billion board feet)	5.40	5.91	6.20	6.39	4.84	6.50	6.73
Veneer & plywood							
Sq. feet per dollar expenditure.....	.635	.898	.898	.898	.840	.880	.900
Volume (billion board feet)	1.50	3.17	3.40	3.50	3.38	4.80	5.07

---

a/ 1961 dollars

Source: 1962 data from [3].

Table 136. Expenditures for Farm Construction and Repairs, and Lumber, Veneer, and Plywood Consumed, 1962 and Projected 1980 and 2000

Item	1962	1980			2000		
		Low	Medium	High	Low	Medium	High
Expenditures (million dollars)[a].	1420	830	865	900	560	770	780
Lumber							
Board feet per dollar expenditure	1.41	1.15	1.15	1.15	0.90	0.90	0.90
Volume (billion board feet).......	2.00	0.96	1.00	1.04	0.50	0.70	0.70
Veneer & Plywood							
Sq. feet per dollar expenditure.......	0.15	0.44	0.46	0.48	0.75	0.78	0.81
Volume (billion board feet).......	0.21	0.36	0.40	0.44	0.42	0.60	0.63

---

[a] 1961 dollars

Source: 1962 data from [3].

Table 137. Railway Mileage, Crossties Used, and Lumber Consumed, 1950-62 and Projected 1980 and 2000

Year	Mileage of track operated		Number of crossties	Lumber per crosstie	Volume (bd. ft.) consumed
	Total	Level on crossties			
	---Thousand---		Million	Bd. ft.	Billion
1950-59[a]......	369.8	343.9	29.5	39	1.26
1960..........	360.6	335.3	17.6	39	0.75
1961..........	357.9	332.9	14.4	39	0.63
1962..........	354.5	329.6	16.3	39	0.70
1980					
Low..........	300.0	279.0	24.2	38	0.92
Medium.......	310.0	288.0	25.3	39	1.00
High.........	320.0	297.0	25.5	40	1.02
2000					
Low..........	290.0	270.0	21.0	38	0.80
Medium.......	300.0	279.0	25.3	39	1.00
High.........	310.0	297.0	26.0	40	1.04

---

[a] Annual average.

Source: Historical data from [3].

Table 138. Lumber, Veneer and Plywood Consumed in Manufactured Products 1948, 1960 and 1962 and Projected 1980 and 2000

(in billions)

Description	1948	1960	1962	1980 Low	1980 Medium	1980 High	2000 Low	2000 Medium	2000 High
Lumber (board feet)									
Household furniture......	1.96	2.09	2.26	2.33	2.45	2.52	2.00	2.69	2.80
Commercial and institutional furniture.........	0.11	0.17	0.18	0.22	0.24	0.24	0.22	0.30	0.31
Consumer goods..........	0.76	0.67	0.68	0.60	0.63	0.64	0.47	0.62	0.64
Commercial equipment.....	0.26	0.22	0.22	0.27	0.29	0.29	0.25	0.33	0.35
Industrial machinery and equipment...........	0.44	0.30	0.29	0.29	0.31	0.32	0.18	0.24	0.25
Miscellaneous............	0.39	0.40	0.62	0.66	0.70	0.72	0.52	0.70	0.72
Total.................	3.91	3.85	4.24	4.38	4.62	4.74	3.65	4.90	5.08
Veneer & plywood (sq ft)									
Household furniture......	0.48	0.69	0.79	1.36	1.45	1.50	1.64	2.33	2.46
Commercial and institutional furniture.........	0.05	0.09	0.10	0.16	0.17	0.18	0.24	0.34	0.36
Consumer goods..........	0.07	0.25	0.32	0.68	0.73	0.75	0.85	1.21	1.28
Commercial equipment.....	0.24	0.22	0.24	0.31	0.33	0.34	0.27	0.39	0.41
Industrial machinery and equipment...........	0.06	0.08	0.09	0.14	0.15	0.15	0.16	0.23	0.24
Miscellaneous............	0.13	0.28	0.35	0.52	0.56	0.58	0.55	0.79	0.83
Total.................	1.02	1.60	1.88	3.17	3.40	3.50	3.72	5.30	5.58

Source: Historical data from [3].

Table 139. Lumber, Veneer and Plywood Consumed in the Construction and Repair of Railroad Cars, 1950-66 and Projected 1980 and 2000

(in billions)

Year	Lumber	Veneer and plywood
	bd. ft.	sq. ft.
1950-54[a/].......	0.50	-
1955-59[a/].......	0.34	-
1960...........	0.24	0.05
1961...........	0.21	0.06
1962...........	0.26	0.05
1980		
Low...........	0.20	0.10
Medium........	0.20	0.10
High..........	0.20	0.10
2000		
Low...........	0.10	0.10
Medium........	0.20	0.10
High..........	0.20	0.11

---

a/ Annual average.

Source: Historical data from [3].

Table 140. Lumber Consumed in Mining, 1950 and 1962, and Projected 1980 and 2000

(billion board feet)

Year	Total	Coal	Other
1950.......	0.84	0.60	0.24
1962.......	0.33	0.18	0.15
1980			
Low......	0.32	0.21	0.13
Medium...	0.33	0.20	0.13
High.....	0.35	0.21	0.14
2000			
Low......	0.30	0.28	0.20
Medium...	0.40	0.22	0.16
High.....	0.41	0.23	0.16

Source: Historical data from [3].

Table 141. Consumption of Lumber, Veneer and Plywood for Shipping and Handling Materials, 1952-62 and Projected 1980 and 2000

Year	Lumber				Veneer & plywood
	Total	Dunnage	Pallets	Boxes & crates	
	----Billion board feet----				Sq. ft.
1952.........	6.12	1.00	0.83	4.29	1.44
1960.........	4.28	0.80	1.56	1.92	1.14
1962.........	4.34	0.84	1.71	1.79	1.22
1980					
Low........	5.23	0.97	3.30	0.96	1.69
Medium.....	5.50	1.00	3.50	1.00	1.80
High.......	5.65	1.03	3.60	1.02	1.86
2000					
Low........	4.09	0.75	2.75	0.59	1.56
Medium.....	5.60	1.10	3.80	0.70	2.20
High.......	5.70	1.15	3.85	0.75	2.34

Source: Historical data from [3].

Table 142. Apparent Consumption of Paper and Board by Grades, 1950-66

(million tons)

Type	1950	1955	1960	1961	1962	1963	1964	1965	1966
Paper									
Newsprint.........	5.9	6.5	7.4	7.4	7.5	7.6	8.1	8.4	9.1
Groundwood........	0.7	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0
Book paper........	2.6	3.0	3.8	3.8	4.0	4.3	4.6	5.0	5.5
Fine paper........	1.2	1.4	1.7	1.9	2.0	2.1	2.2	2.4	2.6
Coarse & industrial paper......	3.7	4.2	4.7	4.8	5.0	5.1	5.2	5.5	5.6
Sanitary & tissue.	1.4	1.8	2.2	2.3	2.4	2.6	2.7	2.8	3.0
Construction paper	1.4	1.6	1.4	1.4	1.4	1.4	1.5	1.6	1.5
Total...........	16.8	19.4	22.1	22.5	23.2	24.0	25.4	26.6	28.4
Board									
Container board...	5.8	7.4	8.2	8.8	9.5	9.8	10.6	11.3	12.5
Bending board.....	3.1	3.9	4.4	4.5	4.9	4.8	5.2	5.4	5.7
Building board....	1.2	1.7	1.9	1.9	2.3	2.1	2.4	2.5	2.4
Other.............	2.1	2.6	2.7	2.8	2.8	2.9	3.0	3.2	3.3
Total...........	12.3	15.6	17.2	18.0	19.1	19.9	21.2	22.3	23.9
Total paper & board	29.1	35.0	39.3	40.5	42.3	43.9	46.6	48.9	52.3

Source: Data from [4].

Table 143. Consumption of Fibrous Materials in the Manufacture of Paper and Baord, 1950-65, and Projected 1980 and 2000

(million tons)

Year	Total	Woodpulp	Waste paper	Other
1950.......	25.9	16.5	8.0	1.4
1955.......	31.8	21.4	9.0	1.3
1960.......	35.7	25.7	9.0	1.0
1961.......	36.6	26.7	9.0	0.9
1962.......	38.6	28.6	9.1	1.0
1963.......	41.1	30.2	9.6	1.3
1964.......	42.5	32.0	9.5	1.0
1965.......	45.1	34.2	9.9	1.0
1980				
Low......	77.3	63.0	13.6	0.7
Medium...	81.4	66.3	14.4	0.7
High.....	85.6	69.8	15.0	0.8
2000				
Low......	122.5	104.1	17.2	1.2
Medium...	133.7	111.9	20.5	1.3
High.....	142.6	121.2	20.0	1.4

Source: Historical data from [4].

Table 144. Consumption of Woodpulp by Type, 1960-66 and Projected 1980 and 2000

(million tons)

Type of woodpulp	1950	1955	1960	1961	1962	1963	1964	1965	1966
Dissolving and special alpha..	0.7	1.0	1.0	1.0	1.1	1.1	1.2	1.2	1.3
Sulfite.........	3.2	3.2	3.1	3.1	3.0	3.1	3.1	3.3	3.3
Sulfate.........	3.4	11.9	15.2	16.1	17.3	18.8	20.9	21.7	23.7
Soda............	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.2	0.2
Groundwood......	2.5	3.0	3.6	3.5	3.7	3.8	3.9	4.3	4.3
Semi-chemical...	0.7	1.4	2.0	2.4	2.5	2.6	2.7	2.9	3.2
Defibrated, exploded & screened	1.1	1.3	1.3	1.3	1.4	1.6	1.6	1.5	1.5
Total woodpulp....	17.1	22.3	26.6	27.8	29.5	31.5	33.8	35.0	37.4

Source: Data from [4].

Table 145. Consumption of Pulpwood in the United States, 1950-66 and Projected 1980 and 2000

(million cords)

Year	Total	U.S. mills	Imports[a]
1950........	33.7	23.6	10.0
1955........	42.0	33.4	8.6
1960........	48.6	40.5	8.1
1961........	50.1	42.2	7.9
1962........	52.5	44.1	8.5
1963........	54.1	46.4	7.7
1964........	58.1	50.1	7.9
1965........	61.8	52.8	9.0
1966........	65.2	55.4	9.8
1980			
Low.......	103.9	92.2	11.7
Medium....	110.3	98.6	11.7
High......	119.3	106.4	12.9
2000			
Low.......	160.0	140.0	20.0
Medium....	174.6	133.3	21.3
High......	193.3	169.3	24.0

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[a] Net imports of paper, board and pulpwood expressed in pulpwood equivalent.

Source: Historical data from [4].

Table 146. Exports of Selected Wood Products from the United States, 1950-66

(million cubic feet)

Year	Logs	Lumber	Veneer	Plywood	Pulpwood	Pulp	Paper & Board	All Products
				SOFTWOOD				
1950	4.60	67.53	0.08	0.21	1.84	9.43	20.01	103.70
1951	0.21	145.37	0.10	0.25	0.88	19.55	33.60	208.96
1952	7.06	93.91	0.07	0.85	1.16	20.24	33.94	157.23
1953	13.67	85.09	0.12	0.62	0.75	15.30	23.29	138.84
1954	16.92	97.06	0.10	0.44	2.79	41.17	36.17	194.65
1955	22.93	108.30	0.12	0.53	4.22	58.08	44.50	238.68
1956	24.63	94.74	0.12	0.95	7.34	47.73	38.76	214.27
1957	17.06	103.48	0.12	0.95	6.87	55.78	43.15	227.41
1958	20.24	91.32	0.14	0.77	6.94	45.65	40.53	205.59
1959	26.65	100.91	0.15	4.67	8.09	57.04	41.68	239.19
1960	33.44	115.17	0.14	0.85	11.02	98.44	46.11	305.17
1961	68.72	102.62	0.14	0.89	12.78	100.28	51.91	337.34
1962	71.98	104.35	0.15	1.08	7.82	99.59	48.32	333.29
1963	139.86	123.35	0.19	1.14	6.26	117.76	54.03	442.59
1964	162.59	134.71	0.34	1.83	6.80[a]	129.03	67.12	502.42
1965	176.71	129.86	1.00	1.97	10.20[a]	112.82	74.00	506.57
1966	209.48	144.07	1.38	3.10	10.20[a]	125.46	82.73	576.42
				HARDWOOD				
1950	3.069	22.29	0.73	0.01	--	1.6	3.53	31.23
1951	3.418	24.50	0.86	0.01	--	3.7	6.40	38.89
1952	3.053	32.48	0.65	0.01	--	4.1	6.95	47.24
1953	4.643	26.23	1.04	0.01	--	3.3	5.11	40.33
1954	5.263	26.79	0.92	0.02	--	9.7	8.49	51.18
1955	3.498	37.91	1.09	0.05	--	14.5	11.12	68.17
1956	5.215	38.29	1.09	0.03	--	12.6	10.30	67.52
1957	5.088	37.73	1.10	0.02	--	15.8	12.17	71.91
1958	6.758	35.60	1.28	0.05	--	13.6	12.11	69.40
1959	5.883	36.06	1.40	0.08	--	18.1	13.16	74.68
1960	8.904	33.55	1.27	0.07	--	32.9	15.37	92.06
1961	7.870	31.13	1.23	0.08	--	35.2	18.24	93.75
1962	11.051	26.35	1.37	0.06	--	36.8	17.87	93.50
1963	11.416	27.01	1.67	0.04	--	45.8	21.01	106.95
1964	10.128	28.08	3.05	0.07	--	52.7	27.42	121.45
1965	12.943	28.18	3.59	0.17	--	48.4	31.72	125.00
1966	12.020	31.09	3.25	0.23	--	53.8	35.45	135.84
				ALL SPECIES				
1950	7.67	89.82	0.81	0.22	1.84	11.03	23.54	134.93
1951	12.63	169.87	0.96	0.26	0.88	23.25	40.00	247.85
1952	10.11	126.39	0.72	0.86	1.16	24.34	40.89	204.47
1953	18.31	111.32	1.16	0.63	0.75	18.63	28.40	179.17
1954	22.18	123.85	1.02	0.46	2.79	50.87	44.66	245.83
1955	26.43	146.21	1.21	0.58	4.22	72.58	55.62	306.85
1956	29.85	133.03	1.21	0.98	7.34	60.33	49.06	281.80
1957	22.15	141.21	1.22	0.97	6.87	71.58	55.32	299.32
1958	27.00	126.92	1.42	0.82	6.94	59.25	52.64	274.99
1959	32.53	136.97	1.55	4.75	8.09	75.14	54.84	313.87
1960	42.34	148.72	1.41	0.92	11.02	131.34	61.48	397.23
1961	76.59	133.75	1.37	0.97	12.78	135.48	70.15	431.09
1962	83.03	130.70	1.52	1.14	7.82	136.39	66.19	426.79
1963	151.28	150.36	1.86	1.18	6.26	163.56	75.04	549.54
1964	172.72	162.79	3.39	1.90	6.80	181.73	94.54	623.87
1965	189.65	158.04	4.59	2.14	10.20	161.22	105.72	631.57
1966	221.50	175.16	4.63	3.33	10.20	179.26	118.18	712.26

a/ Estimated.

Source: Data from [1].

APPENDIX TO CHAPTER VIII

OUTDOOR RECREATION

The Outdoor Recreation Resources Review Commission (ORRRC) was first to develop a model for projecting recreation demand in terms of visits to recreation areas [1]. In explaining the past, as well as projecting to 1976 and 2000, ORRRC used the following variables: (1) per capita real disposable income (thousands of 1960 dollars), (2) per capita intercity automobile travel (thousands of passenger miles), (3) weekly hours of leisure per employed person, and (4) time.

The ORRRC model was used in this study to project recreation visits to Federal and State lands. Further, the model was used, with slight variations, to project the levels of hunting and fishing activities. In particular, a variable was added (metro-urbanization) to account for social and other changes associated with increasing urbanization of the population.

It was assumed, as in the ORRRC studies [1], that general conditions prevailing since 1948 will continue through 1980 and 2000; that is, "high levels of employment, continued productivity gains shared by consumers and all factors of proproduction, no major economic depression and no catastrophic war period."

The following definitions were explained in the body of the text and will not be repeated here: study areas and limitations, population, regions, time, and visits. The following definitions were also used: Income is per capita real disposable personal income (in thousands of 1958 dollars);[1] mobility (historical) data were derived from Transport Economics [8][2] adjusted with new data, and projected mobility data were extrapolated from ORRRC [1, vols. 23, 26]; leisure is weekly hours of leisure per employed person [1, vols. 19, 23, 26]; and metro-urbanization is based upon the past average annual growth rates in metropolitan areas as described by the National Planning Association (NPA) [3, pp. 2-3, 5-759-768]. The NPA base allowed a determination of the geographic as well as the demographic growth of urban areas.

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[1] Source and methodology explained in Chapter II of this report.

[2] And unpublished data.

Year	Metro-urbanization as a percentage of total U.S. population
1965	67.0
1980	69.3
2000	72.6

Variables Considered in Determining Estimating Equations

X_1 = visits to the national parks per 100 population.

X_2 = per capita real disposable personal income (thousands of 1958 dollars).

X_3 = per capita intercity automobile travel (thousands of passenger miles).

X_4 = weekly hours of leisure per employed person.

X_5 = time (1948=1).

X_6 = visits to other areas administered by the National Park Service per 100 population.

X_7 = fishing license holders per 100 persons.

X_8 = metro-urbanization.

X_9 = visits to the national forests, per 100 population.

X_{on} = overnight stays in the national forests as a ratio of total national forest visits.

X_{10} = hunting license holders per 100 population.

X_{12} = visits to wildlife refuges per 100 population.

X_D = interclass differences expressing difference in annual rate of change of metro-urbanization (X_8).

$R^2 \times 100$ = the percentage of variation in the dependent variable during the period covered by the equation.

Equation Summaries

The following equations were used to project visits to recreation areas and levels of hunting and fishing activity in 1980 and 2000.

Recreation areas and activities		Equation	Variable	R^2
National Parks	X_1	$= 8.23$ $+ 0.26125(X_5)$ $+ 0.01733(X_5)^2$	Time	.964
Other NPS areas	X_6	$= 9.78$ $+ 1.61333(X_5)$	Time	.966
National forests	X_9	$= 55.22$ $+ 0.09482(X_2)$ $- 0.00003(X_2)^2$ $+ 0.22235(X_5)^2$	Income-time	.999
Wildlife refuges	$\text{Log } X_{12}$	$= 1.69858$ $- 1.541.27957(\frac{1}{X_2})$ $- 1.77042(\frac{1}{X_5})$	Income-time	.978
Fishing license holders	X_7	$= 25.56$ $+ 0.34982(X_5)$ $- 37.01208(X_8)$ $+ 8,174.07013(\frac{1}{X_2})$ $- 0.97505(\frac{1}{X_5})$	Income-metro-urbanization-time	.885
Hunting license holders	$\frac{1}{X_{10}}$	$= -0.02569$ $+ 0.24013(X_8)$ $+ 0.00263(X_D)$	Metro-urbanization	.969

Other equations, which appear to explain the past but which do not appear valid in projecting the future, are shown below:

Recreation areas and activities	Equation	Variable	R^2
National parks	$\text{Log } X_1 = 0.28363 + 0.02926(X_4) + 0.01529(X_5)$	Leisure-time	.967
Hunting license holders	$\text{Log}_{10} X_{10} = 1.431 - 0.83837(X_8) - 0.01042(X_D)$	Metro-urbanization	.969

Table 147. Attendance at National Parks 1948-65, and Projected 1980 and 2000

Year	Visits to national parks	
	Thousands[a/]	Per 100 persons[b/]
1948......	10,900.3	7.46
1949......	12,612.4	8.48
1950......	13,499.0	8.89
1951......	14,573.4	9.46
1952......	16,440.9	10.51
1953......	16,948.3	10.66
1954......	17,489.0	10.80
1955......	18,409.4	11.15
1956......	19,528.1	11.62
1957......	20,363.0	11.90
1958......	21,170.4	12.16
1959......	21,560.6	12.17
1960......	25,808.9	14.34
1961......	27,021.9	14.76
1962......	32,351.1	17.40
1963......	32,666.2	17.32
1964......	33,350.5	17.43
1965......	35,870.8	18.51
1980......	84,013.4[c/]	35.72
2000......	217,799.3[c/]	70.76

[a/] Excluding Alaska and Hawaii.
[b/] 1950-65 includes Alaska and Hawaii.
[c/] Medium population projection used.

Source: Data from [9, pp. 2; 10, pp. 5-11; 11, pp. 3-9].

Table 148. Visits to National Parks, 1948-65, and Comparison of ORRRC and RRNA Projections, 1976, 1980, and 2000

Year	ORRRC: Visits to all national parks (per 100)	RRNA: Visits to national parks in 48 States (per 100)
1948......	7.73	7.46
1950......	9.20	8.89
1959......	12.69	12.17
1960......	13.24[a]	14.34
1965......	--	18.51
1976......	20.98	--
1980......	--	35.72
2000......	29.10	70.76

---

[a] Projected

Source: [2].

Table 149. Visits to other NPS Areas,[a] 1948-65 and Projected 1980 and 2000

Year	Visits to other areas	
	Thousands[b]	Per 100 persons[c]
1948......	18,556.9	12.70
1949......	18,762.1	12.62
1950......	19,332.3	12.73
1951......	21,985.5	14.27
1952......	30,195.8	19.30
1953......	34,847.0	21.91
1954......	36,190.5	22.35
1955......	37,685.8	22.83
1956......	41,457.4	24.67
1957......	46,997.3	27.47
1958......	43,636.4	25.07
1959......	46,322.0	26.15
1960......	52,390.3	29.11
1961......	58,547.9	31.98
1962......	63,867.9	34.36
1963......	69,067.5	36.61
1964......	74,991.3	39.19
1965......	82,296.0	42.47
1980......	148,223.0[d]	63.02
2000......	293,302.6[d]	95.29

---

[a] Recreational areas, administered by NPS, other than national parks.
[b] Excluding Alaska and Hawaii.
[c] 1950-65 includes Alaska and Hawaii.
[d] Medium population projections used.

Source: Visits to other areas from [9, pp.3-7; 10, pp.5-11; 11, p.13]. Visits per 100 population from [4].

Table 150. Visits to National Forests, 1948-64 and Projected 1980 and 2000

Year	Visits to national forests	
	Thousands	Per 100 persons
1948......	23,905.7	16.36
1949......	25,956.8	17.46
1950......	27,194.1	17.91
1951......	29,720.9	19.29
1952......	32,743.5	20.93
1953......	35,079.3	22.06
1954......	39,955.2	24.68
1955......	45,296.4	27.44
1956......	52,140.0	31.03
1957......	60,368.6	35.28
1958......	67,708.8	38.90
1959......	80,475.5	45.43
1960......	91,325.0	50.74
1961......	100,589.1	54.95
1962......	111,464.3	59.96
1963......	120,936.1	64.10
1964......	132,385.2	69.18
1965......	n.a.	n.a.
1980......	433,026.7 b/	184.11
2000......	958,735.4 b/	311.48

---

a/ Visits: 1948-64 The designated unit was "Number of Visits" and included any person making recreational use of the national forest, but for an unspecified time. Persons merely passing through were excluded. Alaska and Hawaii were excluded.

1965 The designated unit was "Visitor Days of Recreation Use", and includes "recreation use of N.F. land and water which aggregates 12 person-hours. May entail 1 person for 12 hours, 12 persons for 1 hour, or any equivalent combination...." Due to the change of designated units, 1965 data was not included.

b/ Medium population projection used.

Source: Visits to national forests from [7]. Visits per 100 population from [4].

Table 151. Visits to Wildlife Rufuges, 1948-64, and Projected 1980 and 2000

Year	Visits to wildlife refuges	
	Thousands	Per 100 persons
1948......	n.a.	n.a.
1949......	n.a.	n.a.
1950......	n.a.	n.a.
1951......	3,442.3	2.23
1952......	4,261.0	2.72
1953......	4,686.7	2.95
1954......	5,202.4	3.21
1955......	6,974.6	4.23
1956......	7,555.6	4.50
1957......	8,667.7	5.07
1958......	9,114.1	5.24
1959......	9,895.8	5.59
1960......	10,573.8	5.87
1961......	10,994.7	6.01
1962......	10,756.6	5.79
1963......	12,437.6	6.59
1964......	13,907.3	7.27
1965......	n.a.	n.a.
1980......	39,842.9 a/	16.94
2000......	77,873.4 a/	25.30

---

a/ Medium population projection used.

Source: Visits to Wildlife Refuge: U.S. Department of Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, unpublished yearly summaries. These figures exclude Alaska and Hawaii.

Visits per 100 population from [4]. Figures include Alaska and Hawaii.

Table 152. Visits to State Parks, by Region, 1960 and 1965 and Projected 1980 and 2000.

Region	1960 Total visits (mil.)	1960 Visits per 100 population	1960 Ratio: Visits per 100 to natl. rate	1965 Total visits (mil.)	1965 Visits per 100 population	1965 Ratio: Visits per 100 to natl. rate	1980 Visits per 100 population	2000 Visits per 100 population
United States[a/]..	293.8	147.7	100.0	420.5	224.5	100.0		
Northeast......	99.6	222.3	141.0	121.0	254.9	113.5	535.8	1,344.4
North Central..	100.0	193.6	122.8	140.0	258.8	111.5	535.8	1,344.4
South..........	48.2	129.7	82.2	71.6	145.6	64.9	440.4	1,244.7
West...........	45.9	164.6	104.4	87.5	282.3	125.7	803.7	1,566.0

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a/ Excluding Alaska and Hawaii.

Source: Historical data from [5].

Table 153. Fishing License Holders, 1948-65 and Projected 1980 and 2000

Year	Fishing license holders: Thousands	Fishing license holders: Per 100 persons
1948......	14,078.0	9.64
1949......	15,478.6	10.41
1950......	15,766.2	10.38
1951......	16,026.7	10.40
1952......	17,127.9	10.95
1953......	17,652.5	11.10
1954......	18,580.8	11.48
1955......	18,854.8	11.42
1956......	18,702.0	11.13
1957......	19,276.8	11.27
1958......	20,177.6	11.59
1959......	19,879.7	11.22
1960......	19,031.9	10.57
1961......	19,335.8	10.56
1962......	19,345.7	10.41
1963......	19,768.5	10.48
1964......	20,153.7	10.53
1965......	20,428.8	10.54
1980......	32,057.8[a/]	13.63
2000......	57,250.8[a/]	18.60

---

a/ Medium population projections used.

Source: Fishing Licenses, from unpublished summaries, compiled by the Bureau of Sport Fisheries and Wildlife from information furnished by the State Fish and Game Departments, U.S. Department of Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife. Alaska and Hawaii are excluded. Visits per 100 population from [4]. Alaska and Hawaii included.

Table 154. Hunting License Holders, 1952-65 and Projected 1980 and 2000

Year	Hunting license holders	
	Thousands	Per 100 persons
1952......	13,902.4	8.88
1953......	14,803.1	9.31
1954......	14,073.4	8.69
1955......	14,191.5	8.60
1956......	14,461.8	8.61
1957......	14,918.4	8.72
1958......	14,085.8	8.09
1959......	14,126.6	7.98
1960......	13,865.8	7.70
1961......	13,849.2	7.57
1962......	13,709.8	7.38
1963......	13,950.6	7.39
1964......	14,070.5	7.35
1965......	14,278.6	7.37
1980......	16,722.7[a/]	7.11
2000......	20,714.9[a/]	6.73

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a/ Medium population projections used.

Sources: Hunting licenses from unpublished summaries, compiled by the Bureau of Sport Fisheries and Wildlife from information furnished by the State Fish and Game Departments, U.S. Department of Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife. Alaska and Hawaii excluded.

Visits per 100 population from [4]. Alaska and Hawaii included.

Table 155. Regional License Holders Per 100 Persons, 1950-65

Region	1950	1955	1960	1965
Fishing				
United States[a/]....	10.38	11.42	10.57	10.54
Northeast........	5.35	5.98	5.05	4.48
North Central....	15.92	15.92	14.26	13.69
South............	7.84	10.28	10.37	10.55
West.............	14.36	14.69	13.42	14.66
Hunting				
United States[a/]....	n.a.	8.60	7.70	7.35
Northeast........	n.a.	6.07	5.26	5.05
North Central....	n.a.	10.72	9.73	8.88
South............	n.a.	7.97	7.49	7.51
West.............	n.a.	10.39	8.54	8.24

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a/ U.S. total includes Hawaii and Alaska.

Sources: U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, unpublished summaries, from information submitted by the State Fish and Game Departments and [4].

APPENDIX TO CHAPTER IX

LAND OCCUPANCY REQUIREMENTS

Definition of Urban Population Used By the 1960 Census of Population

The definition of urban population used in this study is based on the definition of urban population used in the 1960 Census of Population, as follows:

> ...According to the definition adopted for use in the 1960 Census, the urban population comprises all persons living (a) places of 2,500 inhabitants or more incorporated as cities, boroughs, villages, and towns (except towns in New England, New York, and Wisconsin); (b) the densely settled urban fringe, whether incorporated or unincorporated, of urbanized areas (see section below); (c) towns in New England and townships in New Jersey and Pennsylvania which contain no incorporated municipalities as subdivisions and have either 25,000 inhabitants or more or a population of 2,500 to 25,000 and a density of 1,500 persons or more per square mile; (d) counties in States other than the New England States, New Jersey, and Pennsylvania that have no incorporated municipalities within their boundaries and have a density of 1,500 persons per square mile; and (e) unincorporated places of 2,500 inhabitants or more. In other words, the urban population comprises all persons living in urbanized areas and in places of 2,500 inhabitants or more outside urbanized areas. The population not classified as urban constitutes the rural population.
>
> ...An urbanized area contains at least one city of 50,000 inhabitants or more in 1960, as well as the surrounding closely settled incorporated places and unincorporated areas that meet the criteria listed below...

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1. Incorporated places with 2,500 inhabitants or more.

2. Incorporated places with less than 2,500 inhabitants, provided each has a closely settled area of 100 housing units or more.

3. Towns in the New England States, townships in New Jersey and Pennsylvania, and counties elsewhere which are classified as urban.

4. Enumeration districts in unincorporated territory with a population density of 1,000 inhabitants or more per square mile. (The areas of large nonresidential tracts devoted to such urban land uses as railroad yards, factories, and cemeteries were excluded in computing the population density of an ED.)

5. Other ED's provided that they served one of the following purposes:

   a. To eliminate enclaves.
   b. To close indentions in the urbanized areas of one mile or less across the open end.
   c. To link outlying ED's of qualifying density that were no more than 1 1/2 miles from the main body of the urbanized area [1, Part 1, U.S. Summary, pp. xviii, xix, and xxvi].

Measurements of the Number of Second Homes in 1950 and 1960

The number of second homes in 1950 was assumed to be equivalent to the number of nonresident dwelling units and the number of seasonal dwelling units reported in the 1950 Census of Housing [5, table 17]. The number of second homes in 1960 was assumed to be equivalent to the number of vacant housing units held for occasional use plus the number of seasonal housing units reported in the 1960 Census of Housing [6, table 3]. The 1960 Census of Housing described and compared these housing classifications as follows:

> ...Year-round housing units are units which are usually occupied or intended for occupancy at any time of the year. A unit used only occasionally throughout the year is considered a year-round unit. In resort areas, a unit which is usually occupied on a year-round basis is also considered a year-round unit.
>
> Seasonal units are intended for occupancy during only a season of the year. Included are units intended for summer or winter recreational use, such as beach cottages and hunting cabins; units held for herders, loggers, and cannery workers; and units intended for migratory workers employed in farmwork during the crop season. Although units held for migratory workers were separately identified by the enumerator, they were included with other seasonal units in the tabulations.
>
> Essentially the same definitions were used in the 1950 Census. In 1950, however, units which were temporarily occupied by persons having a usual residence elsewhere (classified as "nonresident" units) were shown as a separate category and, although they were treated as vacant units, they were not classified by year-round or seasonal use as in 1960. It is believed that most of the "nonresident" units in 1950 would have been classified as seasonal.
>
> ...The category tabulated as "held for other reasons" consists of vacant units which are for year-round occupancy and in either sound or deteriorating condition, and which are held for weekend or other occasional use. The intent of this question was to identify homes reserved by their owners as second homes. Because of the difficulty of distinguishing between this category and seasonal vacancies, however, it is possible that some "second homes" were classified as "seasonal" and therefore are included in the category "seasonal"...[6, Part 1, U.S. Summary, p. LIX].

Table 156. Population and Density in Groups of Places Classified According to Size, 1960

Area	Population	Land area in square miles	Population per square mile of land area
UNITED STATES[a]	179,323,175	3,548,974	51
Places of 1,000,000 or more	17,484,059	1,261	13,865
Places of 500,000 to 1,000,000	11,110,991	1,888	5,885
Places of 250,000 to 500,000	10,765,881	2,401	4,484
Places of 100,000 to 250,000	11,652,426	2,728	4,271
Places of 50,000 to 100,000	13,835,902	3,539	3,910
Places of 25,000 to 50,000	14,950,612	5,319	2,811
Places of 10,000 to 25,000	17,568,286	6,939	2,532
Places of 5,000 to 10,000	9,779,714	5,005	1,954
Places of 2,500 to 5,000	7,580,028	5,242	1,446
Other urban territory	10,540,851	5,917	1,781
Rural territory	54,054,425	3,508,736	15
WITHIN URBANIZED AREAS	95,848,487	25,544	3,752
Places of 1,000,000 or more	17,484,059	1,261	13,865
Places of 500,000 to 1,000,000	11,110,991	1,888	5,885
Places of 250,000 to 500,000	10,765,881	2,401	4,484
Places of 100,000 to 250,000	11,652,426	2,728	4,271
Places of 50,000 to 100,000	13,835,902	3,539	3,910
Places of 25,000 to 50,000	8,015,421	2,594	3,090
Places of 10,000 to 25,000	8,330,638	2,873	2,900
Places of 5,000 to 10,000	2,862,099	1,488	1,923
Places of 2,500 to 5,000	1,250,219	856	1,461
Other urban territory	10,540,851	5,917	1,781
OUTSIDE URBANIZED AREAS	83,474,688	3,523,430	24
Places of 25,000 to 50,000	6,935,191	2,725	2,545
Places of 10,000 to 25,000	9,237,648	4,066	2,272
Places of 5,000 to 10,000	6,917,615	3,517	1,967
Places of 2,500 to 5,000	6,329,809	4,386	1,443
Rural territory	54,054,425	3,508,736	15

---

[a] Includes Alaska and Hawaii.

Source: [7, Part 1, U.S. Summary, Table F, p.xx].

Table 157. Changes in Population Density in Urbanized Areas,[a] 1920-60

Year and Size of Population	Population (thousands)	Land area (square miles)	Population per square mile
1920			
70 urbanized areas over 100,000 population..........	34,616	5,261	6,580
61 urbanized areas 50,000-99,999 population....	4,280	1,057	4,050
131 urbanized areas 50,000+ population..........	38,896	6,318	6,160
1940			
98 urbanized areas over 100,000 population..........	52,398	8,919	5,870
92 urbanized areas 50,000-99,999 population....	5,740	1,533	3,740
190 urbanized areas 50,000+ population..........	58,138	10,452	5,560
1960			
160 urbanized areas over 100,000 population..........	91,004	21,500	4,230
109 urbanized areas 50,000-99,999 population....	7,676	2,611	2,940
269 urbanized areas 50,000+ population..........	98,680	24,111	4,090

[a] Urbanized areas are similar to but not exactly comparable with urbanized areas as defined by the U.S. Bureau of the Census.

Source: [4, tables 5-2, 3, and 4].

Table 158. Population and Land Area of Urbanized Areas in the United States, 1950 and 1960

Area	1960 (213 areas)[a]				1950 (157 areas)			
	Population				Population			
	Number (thou)	Percent distri.	Land area (sq.mile)	Population per square mile	Number (thou)	Percent distri.	Land area (sq.mile)	Population per square mile
Total United States.........	95,848	100.0	25,544.3	3,752	69,252	100.0	12,804.6	5,408
In central cities.........	57,975	60.5	10,837.7	5,349	48,377	69.9	6,213.2	7,786
In urban fringe.	37,873	39.5	14,706.6	2,575	20,875	30.1	6,591.4	3,167

a/ Includes Honolulu, Hawaii.

Source: [7, Part 1, U.S. Summary, table 22].

Table 159. Urban Population Densitites in the 48 Contiguous United States,[a] 1960

Region	Urban land (thou.acres)	Urban Population (thou. persons)	Urban Population per acre	Index (U.S.= 100)
Northeast..............	4,815	35,840	7.44	141
North Central..........	6,553	35,481	5.41	103
South..................	8,233	32,160	3.91	74
West:[a]	4,055	21,217	5.23	99
Montana..............	53	338	6.38	121
Idaho................	74	317	4.28	81
Wyoming..............	36	187	5.19	98
Colorado.............	202	1,293	6.40	121
New Mexico...........	171	627	3.67	70
Arizona..............	288	971	3.37	64
Utah.................	196	667	3.40	65
Nevada...............	46	201	4.37	83
Washington...........	427	1,943	4.55	86
Oregon...............	238	1,100	4.62	88
California...........	2,324	13,573	5.84	111
United States[a]........	23,656	124,699	5.27	100

a/ Excluding Alaska and Hawaii.

Source: Estimates of urban land area based on unpublished estimates by the U.S. Department of Agriculture, Economic Research Service, Land Resources Branch. Estimates of urban popualtion based on [7, Part 1, U.S. Summary, table 20]. Regional population totals do not add up to U.S. total because of rounding.

Table 160. Mileage of Rural Highways in the United States, 1960-65[a]

(in thousands of miles)

Item	1960	1961	1962	1963	1964	1965
State systems..........	644	649	654	656	659	663
Locally controlled highways................	2,345	2,346	2,351	2,347	2,344	2,346
National park, forest reservation, etc........	112	116	120	121	127	150
State park, forest,..... reservation, toll, etc..	15	16	20	21	22	23
Total rural mileage.....	3,116	3,127	3,144	3,146	3,153	3,183

---

[a] Mileages include Alaska and Hawaii; however, in 1965, these two States had a combined mileage of only 8,539 miles of rural highways. Items may not add to total rural mileage because of rounding.

Source: [13, pp. 123-4].

Table 161. Rural Land Withdrawn for Transportation Uses, 1959 and 1964

Region	1959	1964	Average annual growth rate 1959-64
	-- Thous. acres --		Percent
Northeast.........	1,960	1,973	0.13
North Central.....	10,417	10,593	0.34
South............	7,313	7,460	0.40
West:[a]	5,439	5,667	0.82
Montana.........	728	728	0.00
Idaho..........	280	284	0.28
Wyoming.........	523	647	4.35
Colorado........	652	672	0.61
New Mexico......	395	402	0.35
Arizona.........	286	296	0.69
Utah...........	235	252	1.41
Nevada..........	441	450	0.40
Washington......	327	332	0.20
Oregon..........	398	415	0.84
California......	1,174	1,189	0.25
United States[a]...	25,129	25,693	0.44

---

[a] Excluding Alaska and Hawaii.

Source: Estimates for 1959 from [8, table 20]. Estimates for 1964 based on unpublished estimates by the U.S. Department of Agriculture, Economic Research Service, Land Resources Branch. These estimates slightly understate rural land areas withdrawn for transportation uses because of exclusion of some land defined as urban by the U.S. Department of Agriculture, but rural by the U.S. Census of Population and in Chapter IX of this report.

Table 162. Estimated Rural Right-of-Way Requirements for Completion of the Interstate Highway System, 1965

Region	Rural interstate Traveled Way, without full access control (miles)	Estimated right-of-way required to complete the system (thous. acres)
Northeast............	1,414	42
North Central........	4,228	127
South..............	7,651	230
West:a/	7,009	210
Montana............	1,060	32
Idaho..............	378	11
Wyoming............	522	16
Colorado...........	511	15
New Mexico.........	929	28
Arizona............	1,118	34
Utah...............	671	20
Nevada.............	265	8
Washington.........	440	13
Oregon.............	235	7
California.........	880	26
United States a/......	20,302	609

a/ Does not include Alaska and Hawaii.

Sources: [12, p. 16]. Right-of-way requirements estimated by Robert R. Nathan Associates, Inc., at 30 acres per mile, based on right-of-way information on the Interstate Highway System reported in [9, p.75].

Table 163. Total Second Homes and Second Homes per Thousand Population, by Region, 1950 and 1960

Region	Total Second Homes		Average annual growth rate	Second homes per thous. population		Index 1960 (U.S. = 100)
	1950	1960		1950	1960	
			Percent			
Northeast......	480,779	705,111	3.9	12.18	15.78	140
North Central..	313,128	548,537	5.8	7.04	10.63	94
South..........	214,266	469,075	8.2	4.54	8.53	76
West:a/	169,783	294,541	5.7	8.68	10.83	96
Montana......	6,361	14,091	8.3	10.76	20.91	186
Idaho........	6,169	14,837	9.2	10.47	22.24	198
Wyoming......	2,512	6,545	10.0	8.63	19.83	176
Colorado.....	21,006	28,690	3.2	15.85	16.36	145
New Mexico...	5,047	10,110	7.2	7.41	10.63	94
Arizona......	7,451	17,323	8.8	9.93	13.30	118
Utah.........	2,512	5,518	8.2	3.65	6.20	55
Nevada.......	1,025	2,573	9.6	6.41	9.03	80
Washington...	24,566	42,372	5.6	10.33	14.85	132
Oregon.......	14,296	23,612	5.1	9.40	13.35	119
California...	78,838	128,870	5.0	7.45	8.20	73
United States a/	1,177,956	2,017,264	5.5	7.78	11.25	100

a/ Excluding Alaska and Hawaii.

Sources: The number of second homes in 1950 was obtained by adding the number of nonresident dwelling units and the number of seasonal dwelling units reported in [5, Part 1, U.S. Summary, table 17]. The number of second homes in 1960 was obtained by adding the number of vacant housing units held for occasional use and the number of seasonal housing units reported [6, Part 1, U.S. Summary, table 3].

Table 164. Projected Second Homes Per Thousand Population and Total Second Homes, 1980 and 2000

Region	Second homes per thousand population	Total second homes (in thousands)					
		1980			2000		
	1980 & 2000	Low	Medium	High	Low	Medium	High
Northeast.....	21	1,128	1,165	1,224	1,344	1,462	1,656
North Central.	15	901	931	977	1,091	1,187	1,300
South.........	15	1,065	1,100	1,155	1,328	1,444	1,636
West:a/.......	--	684	707	739	920	1,001	1,132
Montana.....	28	22	22	23	27	29	33
Idaho.......	30	23	24	25	29	31	35
Wyoming.....	26	9	10	10	12	13	15
Colorado....	22	53	55	57	67	73	83
New Mexico..	15	19	20	21	28	31	35
Arizona.....	18	40	42	44	60	66	74
Utah........	15	19	19	20	27	29	33
Nevada......	15	10	10	10	12	13	14
Washington..	20	68	70	73	85	93	105
Oregon......	18	41	42	44	51	55	62
California..	15	380	393	412	522	568	643
United States a/		3,778	3,903	4,095	4,683	5,094	5,724

---

a/ Excluding Alaska and Hawaii.

Table 165. Rural Second Homes, 1960 and Projected a/ 1980 and 2000

(in thousands)

Region	1960 Estimated		1980			2000		
	Number	Rural as percent of total	Low	Medium	High	Low	Medium	High
Northeast.......	550	78	902	932	979	1,075	1,170	1,325
North Central...	490	89	721	745	782	873	950	1,040
South...........	361	77	852	880	924	1,062	1,155	1,309
West:b/	242	83	546	566	591	738	799	904
Montana.......	13	89	18	18	18	22	23	26
Idaho.........	13	91	18	19	20	23	25	28
Wyoming.......	6	88	7	8	8	10	10	12
Colorado......	25	89	42	44	46	54	58	66
New Mexico....	8	77	15	16	17	22	25	28
Arizona.......	12	69	32	34	35	48	53	59
Utah..........	4	81	15	15	16	22	23	26
Nevada........	2	87	8	8	8	10	10	11
Washington....	39	92	54	56	58	68	74	84
Oregon........	20	86	33	34	35	41	44	50
California....	100	78	304	314	330	418	454	514
United States b/.	1,643	81	3,021	3,123	3,276	3,748	4,074	4,578

---

a/ Projected at 80 percent of total second homes.
b/ Does not include Alaska and Hawaii.

Source: Estimated 1960 data from [6].

Table 166. Total and Estimated Rural Land Areas Controlled by the Department of Defense and Used for Military Purposes, June 30, 1966

Region	Total DOD land area				Estimated rural DOD land area			
	Total	Army	Navy	Air Force	Total	Army	Navy	Air Force
	---------- Acres ----------				---------- Thousand acres --			
Northeast.....	421,443	267,439	57,193	96,811	386	247	43	96
North Central.	1,206,796	594,711	107,219	504,866	1,130	550	81	499
South.........	3,924,703	2,392,534	509,626	1,022,543	3,606	2,211	385	1,010
West:.........	19,148,594	8,283,819	3,267,054	7,597,721	17,627	7,654	2,466	7,507
Montana.....	41,395	6,663	6	34,726	40	6	*	34
Idaho.......	131,141	11,502	28	119,611	129	11	*	118
Wyoming.....	44,243	9,745	9,324	25,174	41	9	7	25
Colorado....	377,535	278,262	63,053	36,220	341	257	48	36
New Mexico..	4,235,315	4,114,666	119	120,530	3,921	3,802	*	119
Arizona.....	3,808,277	1,054,248	5,263	2,748,766	3,694	974	4	2,716
Utah........	2,411,588	1,358,840	91,480	961,268	2,275	1,256	69	950
Nevada......	3,262,933	8,183	233,300	3,021,450	3,169	8	176	2,985
Washington..	412,221	356,545	28,401	27,275	377	329	21	27
Oregon......	88,878	21,088	64,721	3,069	71	19	49	3
California..	4,335,068	1,064,077	2,771,359	499,632	3,569	983	2,092	494
United States[a]	24,701,536	11,538,503	3,941,092	9,221,941	22,749	10,662	2,975	9,112

---

a/ Includes Alaska and Hawaii.
* Less than 1,000 acres.

Sources: Total DOD land area from [11, tables 20, 24, and 28]. Estimates of rural DOD land area by Robert R. Nathan Associates, Inc., based on proportions of rural land to total land used for military functions by the Army, Navy and Air Force reported in [14, p.267]. Land areas reported and definitions used in [11] are not exactly comparable with those used in [14].

Table 167. Acreage of Military Real Property Controlled by the Department of Defense June 30, 1954-64

Year	Acres
1954[a]	24,172,739
1955	27,179,180
1956	27,081,449
1957	27,350,954
1958	26,796,409
1959	25,324,292
1960[b]	28,646,052
1961	26,594,994
1962	27,302,314
1963	26,791,392
1964	28,165,035

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a/ As of 31 December 1954.
b/ Beginning with 1960, data for Alaska and Hawaii are included in United States; previously these data were included in Possessions.

Source: [10, p.3].

APPENDIX TO CHAPTER X

WATER USE

Population Served by Public Water Systems

In projecting the population served by public water systems, use was made of population data collected by the U.S. Geological Survey in the 1960 survey [3] and the projections of total and urban populations presented in Chapter II. First, the relationship between total population, urban population, and populations served by public supplies was determined for 1960. The relationship determined was:

$$\frac{\text{Total Population-Urban Population}}{\text{Population Served}}$$

Second, this ratio was applied to the difference between projected total and urban populations in 1980 and 2000. The resulting estimates of the proportion of rural population which would be served by public systems were added to the projections of urban populations. This procedure assumed that all urban populations will be served by water systems and that the proportion of rural population served by public systems will remain constant.

Projections of the number of urban places (communities of 2,500 or more) in each region were required to project water requirements. These projections were made graphically on the basis of 1950 and 1960 census data [2].

Projections of Water Requirements

Although projections of only the industrial water from public supplies and the consumption of water from public supplies were made using estimating equations, an attempt was made to determine equations for both municipal and domestic uses and irrigation uses of water.

In the case of municipal and domestic water uses, an equation was determined which explained the use of water in 1960 reasonably well ($R^2 = .835$). As indicated in the text of Chapter X, the important variables related to personal

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income and population density. Because the nature of the data required cross-section analysis, however, attempts to project future consumption on the basis of this equation resulted in unreasonably strong income efforts which produced unrealistically high per capita use projections. For this reason, the equation was discarded and the more conventional procedure, assuming constant per capita use, was adopted [1].

In regard to irrigation uses of water, scatters were made of a number of possible explanatory variables, including agricultural product originating, average humidity, acres under irrigation, etc. Dependent variables were specified in terms of absolute use and use per acre.

As might be expected, variations in water usage were significantly correlated only with acres under irrigation. In order to avoid problems of estimating errors, it was therefore decided to use the ratio-usage factor approach to making projections.

In using the estimating equations for both the industrial use of water from public supplies and consumption of water from public supplies, it was decided to project water requirements for only the major census regions. Because of the relatively small number of observations (14 regions), the equations were not sufficiently sensitive to allow State projections. In order to determine State requirements, the West (census region) was disaggregated by assuming that the 1960 State/regional ratios would remain constant to 1980 and 2000.

Table 168. Statistical Relationships Between Selected Independent Variables and Industrial Water from Public Supplies, and the Consumption of Water from Public Supplies, 1960

Use of industrial water from public supplies	Percent of Variation Explained
$X_1 = -12.14 + .01958\,X_2 + .00033\,(X_3)^2 + 1{,}303.40509\,X_4$	0.999
Consumption of water from public supplies	
$\text{Log } X_5 = 1.039 + 8.29482\,(1/X_3) + 5.06547\,(1/X_6) - 0.77640\,\text{Log } X_7 - 0.04082\,(1/X_7)$	0.929

Description of Variables

X_1 = Industrial water provided by public supplies

X_2 = Regional manufacturing product originated

X_3 = Regional number of urban places

X_4 = Ratio of regional manufacturing product originated to all nonagricultural product

X_5 = Consumption of water from public supplies per capita of population served

X_6 = Regional population per urban place

X_7 = Ratio of regional industrial water provided from public supplies to water provided for municipal and domestic uses

Table 169. Urban Places, by Region, 1950-60 and Projected 1980 and 2000

Region	Number of urban places				Population per urban place			
	1950	1960	1980	2000	1950	1960	1980	2000
					Thousands			
United States[a/].....	4,906	5,391	6,088	6,582	19.7	23.2	29.7	38.2
Northeast.........	1,251	1,348	1,610	1,830	25.1	26.6	28.4	32.1
North Central.....	1,506	1,605	1,744	1,855	18.9	22.1	26.9	34.5
South.............	1,501	1,651	1,826	1,933	15.3	19.5	28.2	38.4
West:[a/]...........	648	787	894	953	21.6	27.7	41.1	56.9
Montana.........	27	30	34	38	9.6	12.7	14.1	18.4
Idaho...........	30	34	43	47	8.4	9.3	10.7	13.8
Wyoming.........	19	19	20	21	7.6	9.8	12.5	17.6
Colorado........	44	51	58	61	18.9	25.4	36.4	49.2
New Mexico......	32	34	36	37	10.7	18.4	30.6	50.3
Arizona.........	28	35	39	40	14.9	27.7	51.3	81.0
Utah............	37	39	40	41	12.2	17.1	26.5	40.0
Nevada..........	9	12	15	17	10.2	16.8	37.3	46.5
Washington......	73	84	101	115	20.6	23.1	26.2	33.0
Oregon..........	59	61	63	65	13.9	18.0	26.5	36.9
California......	290	388	445	471	29.4	35.0	52.8	73.3

---

a/ Excludes Alaska and Hawaii.

Source: Historical data from [2].

Table 170. Irrigated Acreage and Usage Factors, by Region 1960

(Gallons/acre/day, unless noted)

Region	Usage factors			Acres irrigated	Percent of total acres irrigated	Surface water delivery ratio
	Delivered	Consumption	Conveyance loss			
				Thous.		Percent
Northeast........	459	434	0	170	0.44	53
North Central....	1,069	735	396	4,102	10.52	47
South............	1,197	864	260	10,238	26.25	20
West:[a/]..........	--	--	--	24,490	62.79	65
Montana........	2,550	1,200	850	2,000	5.13	98
Idaho..........	3,437	1,406	1,563	3,200	8.21	78
Wyoming........	2,214	1,357	929	1,400	3.59	100
Colorado.......	2,812	1,500	291	3,200	8.21	80
New Mexico.....	1,936	1,398	613	930	2.38	50
Arizona........	3,615	2,231	846	1,300	3.33	36
Utah...........	2,833	1,917	642	1,200	3.08	88
Nevada.........	2,576	1,454	576	660	1.69	88
Washington.....	3,700	1,300	1,000	1,000	2.56	90
Oregon.........	3,000	1,750	938	1,600	4.10	96
California.....	2,250	1,750	563	8,000	20.51	52
United States[a/]..	--	--	--	39,000	100.00	--

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a/ Excludes Alaska and Hawaii

Source: 1960 data from [3, pp.16-17].

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